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ABSTRACT

This publication is a text and reference manual for operating personnel of both large and small wastewater lagoon systems with support from the Environmental Protection Agency (EPA). As a text, this inservice training manual is intended to be used in a correspondence course wherein the trainee or operator would read and study each chapter before completing the examination for that chapter. The first two sections explain how to study and the examination instructions. Other sections include various areas of wastewater lagoon system management such as wastewater collection systems, sewage lift stations and pumping equipment, composition and characteristics of wastewater, screening devices, flow measuring, stabilization ponds, public relations, maintenance, and NPDES requirements and laboratory testing. The tests at the end of each chapter consist of multiple choice and true-false questions. The text contains some diagrams and black and white pictures. (MR)

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WASTEWATER LAGOON SYSTEMS

A FIELD STUDY TRAINING PROGRAM

For the:

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER PROGRAMS
WASHINGTON, D.C.

Prepared By:

WATER & WASTEWATER TECHNICAL SCHOOL
NEOSHO, MISSOURI

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SE 023 898

A Field Study Training Program

on

WASTEWATER LAGOON SYSTEMS

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FOREWARD

This manual has been prepared as a text and reference for operating personnel of lagoon systems with support from the Environmental Protection Agency Office of Water Programs under Grant No. T900507-01-0.

The trainee or operator should read each chapter and study its contents thoroughly before completing the examination for that chapter. The manual should be maintained in an area where it can be used as questions later appear. The manual can be utilized as a text for the correspondence course and as a ready reference for day-to-day operations after the course has been completed.

Materials contained in this manual were derived from many sources, including lagoon sampling and monitoring programs conducted by the Water and Wastewater Technical School, and by experienced operational personnel.

Your comments and ideas to improve the course context will be appreciated.

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CORRESPONDENCE COURSE

WASTEWATER LAGOON SYSTEMS

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INTRODUCTION

Traditionally, the purpose of wastewater treatment has been to reduce the objectionable characteristics of sewage, so that it will not create a nuisance or be harmful or injurious to public health. Through proper design and operation, treatment plants can stabilize sewage and render it safe for domestic, commercial, industrial, agricultural, recreational or other beneficial uses.

The need for qualified operators is now well recognized by most people working in pollution control. The skills, personal attitudes and technical knowledge required by this operator are not, however, as easily defined and, in fact, are quite different in various regions of the country--or are they?

First, let's define what an operator is. An operator is a person (man or woman) who has the knowledge, skills, and desire to operate a water or sewage treatment plant to the specifications of its design.

Not many years ago, an engineer could drive what type of water and sewage plant the city needed. Most plants were designed in a similar fashion using well-studied technology, and operational skills of these facilities were also reasonably well defined.

Well, not today! The sophistication of our sewage plants in recent years has been tremendous. With tertiary treatment coming into fruition as our society demands better waste treatment, the education and skills of "operators" are increasing also.

With tertiary treatment, simply defined, as any combination of physical, chemical, or biological treatment after secondary treatment, the pandora's box of technological developments has been opened upon our cities and industries

and the operator who runs them. Physical-chemical treatment for nutrient removals, activated carbon treatment for color and pesticide removal, denitrification procedures, ammonia stripping and other sophisticated waste treatment ideas are becoming commonplace in our communities.

The men required to operate these systems cannot and must not receive training ideas of 50 years ago for this new technology to be transferred for today's needs. This course is aimed at helping you the operators of both large and small wastewater lagoons to produce a better effluent from your operation.

HOW TO STUDY

The four key ideas to good study habits are:

1. Your attitude
2. Where you study
3. Method you use
4. Results obtained

Your Attitude

The most important aspect of study is the feeling which you have before starting to study. The reason you are taking this course and the benefits to be derived for you after you finish are things worth thinking about as you begin your study. What do you hope to gain during the study period? After you have agreed (with yourself) to study for a time period of say 50 minutes, hold yourself to that period and do not cheat yourself by quitting sooner. Clear your mind of thoughts about other things and scan over the entire subject material you are to study. Next, read or observe the material taking notes of important words or ideas presented in the lesson. After completing the unit of study ask yourself the question, "What were the key points covered and how do they apply to my job?"

The two key ideas on adjusting your attitude are first, the desire to study and second, is the perseverance to finish the study unit. Both attitudes can be developed by hard work on your part!

Where you Study

The place where you study often makes little difference if the desire to study is strong enough. However, the room should be adequately lighted,

properly ventilated, and comfortably furnished. The important thing is to have a definite spot of your own, for most students find that studying in the same place encourages concentration.

Ideally, the room in which you study should be quiet, secluded, and free from distraction. The trick is to learn to shut out all other thoughts and give your undivided attention to what you are studying.

Most people study best at a desk or table, using a straight chair that is comfortable, but not restful. An easy chair or sofa is not conducive to study, for it encourages relaxation and will make you drowsy.

The Study Method

Your study schedule should be as definite as the schedule by which you work, eat, and sleep, but it should also be flexible enough to allow changes to meet daily demands.

By all means take a five or ten-minute break when your study periods are longer than an hour. A brief rest will give you renewed vigor and determination when you return to your studies.

Perhaps the most important point when planning a study schedule is regularity. You will not gain more by studying twice as long the next night. Plan to study at regular intervals for at least an hour at a time. Use the following chart to organize your study time. Decide what days and what time of day you can devote to study; then fill in the spaces accordingly.

MY STUDY SCHEDULE (To be filled in by you)

DAY	TIME	NO. OF HOURS
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		
Saturday		
Sunday		
Total No. of Hours per Week		

Supplies

Your study area should be equipped with all the necessary supplies. Books, a dictionary, information blanks, answer paper, envelopes, note-paper, pencils, and pens should all be within easy reach. Keep your work space uncluttered and have a place for everything. When you finish for the day, put everything back in its place to avoid time lost in looking for supplies the next time you study.

A reliable dictionary is a wise investment. Get into the "dictionary habit". By looking up a word when you are in doubt about its meaning, you will gain not only a better understanding of the material you are reading, but also a greater facility in the use of the words.

There are three steps in study reading: (1) scanning, (2) reading for understanding, and (3) reviewing. At first, it may seem like too much work for you to study one text three times, but it really isn't. These three readings may take less time than one slow reading, and they will cut down on the amount of time you will spend later in reviews.

Read as rapidly as you can, but make sure that you understand every word, every reference, every illustration. When you have difficulty understanding a section, read on and you will undoubtedly gain a new perspective on the material that was not clear.

As you read along, challenge yourself by converting the statements into question form. Ask yourself, why, who, what, when, and where. Asking yourself questions helps you to understand what you read and to remember what you learn.

To get the most out of your reading, note taking is a must. Jot down the important points in a notebook.

As a final review, read the text again at a normal pace, and spend more time on the parts that were not clear to you on your first reading.

This study method will help you get the most out of your texts. It will help you to learn, and to remember what you learn. Once you have learned how to read effectively, you will be surprised how much more enjoyable studying becomes. Get used to following directions carefully and thoroughly. It is only natural that you will be most eager to study the sections of your courses which are most closely related to your job objectives. But even when you cannot see the immediate advantage of some particular subject, you can be sure that the material was included in your course for a definite purpose. Each text brings you a step closer to your goal.

Remember, diligent application to the study task that lies ahead will pay limitless dividends in the future.

Your Results of Study

After you have the proper attitude for study, have a good study place,

and have utilized a few of the methods discussed above, ask yourself the question, "What do I know now that I did not know before studying the material?" Also, think about what was presented as key ideas in the material and how they will help you in your plant work.

EXAMINATION INSTRUCTIONS

What to Do Next

1. Read the Foreward, Introduction, How to Study, and Examination Instructions sections before starting Chapter I of your correspondence course on Wastewater Lagoon Systems.
2. After reading and studying the text in each chapter, complete the examination at the end of that chapter using the answer sheets provided in the packet. Be sure to sign your examination answer sheet.
3. Mail your answer sheets to the Water and Wastewater Technical School using the envelopes provided. Be sure to put a return address on the envelopes. Your instructor reviews your work, makes helpful suggestions, and sends you supplementary instructions.

You may study as rapidly or as slowly as you wish, but it is best to move through your studies fast enough to complete your examinations at regular intervals.

Final Examination

The purpose of the final examination is to test your understanding of the material you have studied throughout your course of study.

As you master each text in your course, the final examination will be of equal difficulty, as earlier examinations were.

Diplomas and Certificates

Here is the day you have been working toward, the day you complete your course, the day you are entitled to your diploma for the Wastewater Lagoon Course.

A diploma or certificate represents more than a sheet of paper. It is something you will treasure, for it represents a substantial accomplishment on your part. It means that you have invested many hours constructively to prepare yourself for a better future, to get ahead in your chosen field.

When you complete this course, you will receive a diploma with your name and the title of the course on it. The diploma carries the seal of the Water and Wastewater Technical School, along with the seal of the National Association of Trade and Technical Schools, and will have the date awarded, and the signature of the president of the school. Should you be taking the course for college credit, a transcript of your final grade will be forwarded to you.

CHAPTER I

WASTEWATER COLLECTION SYSTEMS

Chapter I

Wastewater Collection Systems - Lagoon Operations

Facilities for handling wastewater are usually considered to have these major components or parts: collection, treatment, and disposal. These three components make up the "sewerage" system or wastewater facility. This training program is directed primarily to plant operators of small towns or cities and to those operators who maintain lagoons that may be located in remote areas. This includes, but is not limited to, facilities in National Parks or Forests, rest areas for highway departments, and for any industries which may operate their own wastewater treatment systems.

This chapter will deal with the collection of wastewater. A wastewater collection system may be described as a network of pipes and accessories designed to gather and transport domestic and industrial wastes to a treatment facility or to a place of final disposal. The piping systems vary according to the uses for which the system is designed. The most common system is the sanitary sewer and it consists generally of house sewers (lines), laterals, sub-mains, mains (trunk sewers) and outfall sewers. Maintenance of the collection system will also be dealt with in this chapter.

Purpose of Collection

The proper collection and treatment of sewage before it is discharged is essential to (1) prevent pollution of receiving body of water by harmful bacteria, and (2) protect marine life against deficient oxygen supplies. Proper treatment of waste starts in the collection system, for everything that enters the collection system finds its way to the treatment plant.

Types of Systems

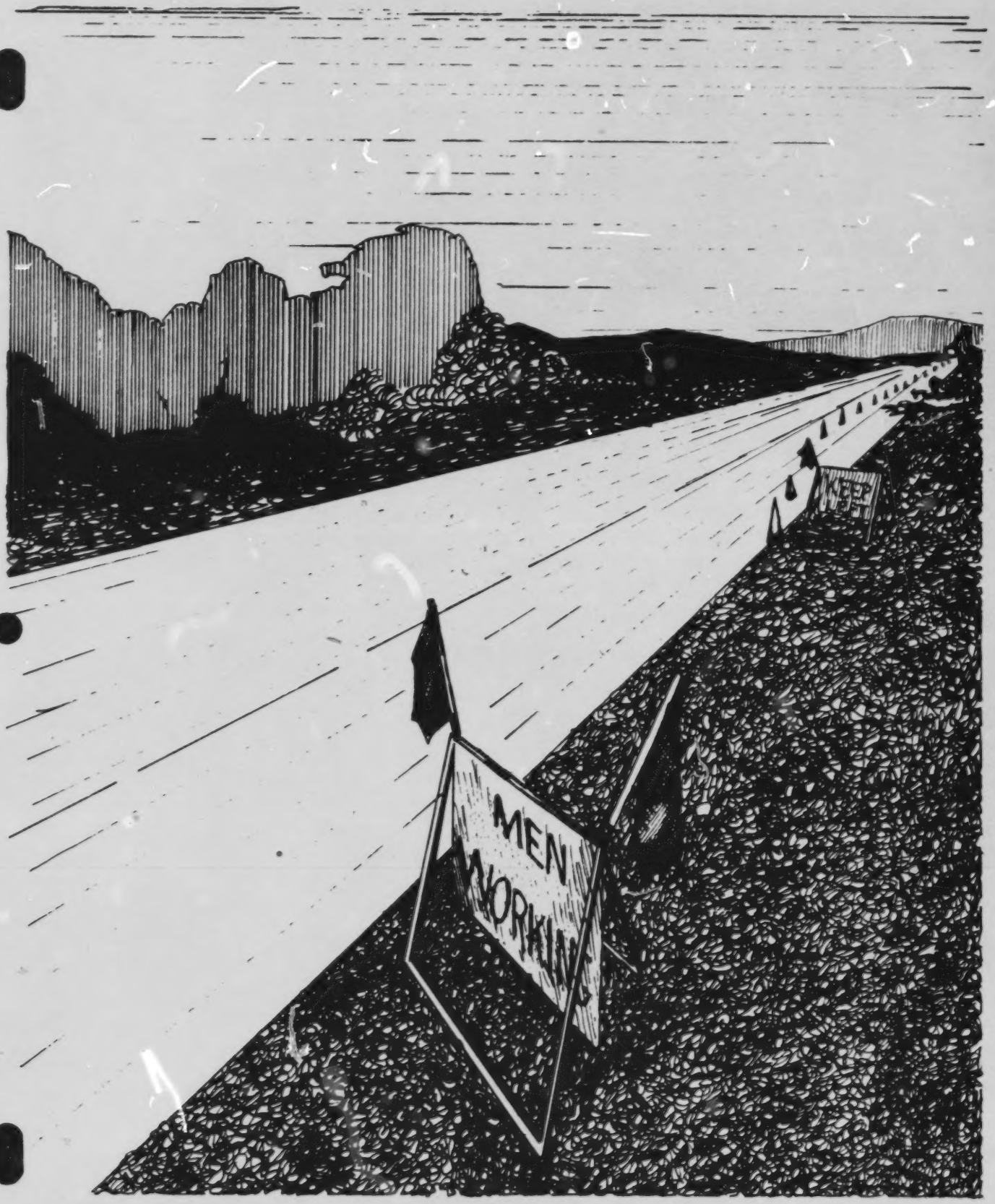
Sanitary, Storm, and Combined Sewers

For most sewerage systems the sewer coming into the treatment plant carries wastes from households and commercial establishments in the city or district, and possibly some industrial waste. This type of sewer is called a sanitary sewer. All storm runoff from streets, land, and roofs of buildings, is collected seperately in a storm sewer, which normally discharges to a water course without treatment. In some areas only one network of sewers has been laid out beneath the city to pick up both sanitary wastes and storm water in a combined sewer. Treatment plants that are designed to handle the sanitary portion of the wastes sometimes become overloaded during storms due to inadequate capacity, allowing untreated or partially treated wastes to be discharged into receiving waters. Separation of combined sewers into sanitary and storm sewers is very costly and difficult to accomplish.

Even in areas where the sanitary and storm sewers are separate, infiltration of groundwater or storm water into sanitary sewers through breaks or open joints can cause high flow problems at the treatment plant. Replacement or sealing of leaky sections of sewer pipe is called for in these cases. The treatment plant operator is generally the first to know about infiltration problems because of the unusually high flows he observes at the plant during periods of storm water runoff.

Velocities

Sanitary sewers are normally installed at a slope sufficient to produce a velocity of at least two feet per second when flow is at one-half or full depth.


MEN
WORKING

While it has been found that a velocity of one foot per second is sufficient to prevent deposition of sewage solids, it is necessary to have the higher velocity to prevent deposition of mineral matter such as sand and gravel. If minimum velocities are not attained, the settling out of the solids will cause partial stoppages which may cause a sluggish flow which permits the sewage to become septic prior to reaching the treatment facility. Septic sewage causes foul odors and is much more difficult to treat when it reaches the treatment facility. Stoppages can be removed by rodding, flushing lines with fire hoses or by using other more modern sewer cleaning methods. When situations arise that do not justify correction of the gradient in the line, odor control may become necessary. The most common method used is the addition of chlorine. The chlorine combines with the odor producing gas (hydrogen sulfide) and the products formed do not smell.

To prevent erosion of the invert of the sewer by abrasive material carried in the sewage, velocities in excess of 8 feet per second should be avoided. The following table gives minimum grades to be used in laying sewer lines to provide a minimum velocity of 2 feet per second.

Pipe Size, Inches	Slope, in Inches per 100 feet	Capacity Gallons per Day
4"	12.0"	115,000
6"	7.2"	260,000
8"	4.8"	460,000
10"	3.4"	700,000
12"	2.6"	1,000,000
15"	1.8"	1,600,000
18"	1.4"	2,300,000
21"	1.2"	3,200,000
24"	1.0"	4,100,000

I-6

Construction Materials

In current practice, materials used in the construction of sewer lines include the following:

1. Vitrified clay pipe
2. Precast concrete pipe
3. Monolithic concrete pipe
4. Cast iron pipe
5. Steel pipe, both welded and corrugated
6. Asbestos-cement pipe
7. Plastic pipe

Jointing

Various types of joints are available for all of the above materials; however, the rubber or plastic compression or slip joint is considered best.

Laying Pipe

When a construction or repair job in a street is required, traffic should be warned by one or more of the three following procedures: (1) A flagman directing traffic, (2) High-level signs and flags far enough ahead of the job to adequately alert drivers, (3) Traffic cones arranged to guide traffic around work areas. A sufficient number of workmen, necessary repair material and adequate equipment should be on hand in order to quickly and efficiently complete the repair.

In constructing sewers, it is customary to lay the pipe with the bell ends of the pipe pointing up-grade. One advantage of this is that the layed pipe helps serve as a drain in case of storm or ground water level problems. Laying

THIS WILL WORK

pipe up-grade also permits the spigot to rest securely in the bell, thereby assuring a better joint.

Water and sewer lines should never be laid in the same ditch. The two lines should be laid at least 9 feet apart. At crossover points, the water line should always be on top. There should be 6 feet between the two lines or the sewer line should be of pressure pipe for 6 feet on either side of the crossover point when the minimum distance cannot be met.

Sheeting and Bracing

When trenches are cut in clay soil, shoring is sometimes needed. Where excavation is made in unstable ground which tends to crumble and cave, sheeting and bracing should always be used to protect the workman from sudden slides and cave-ins. Sheeting also makes it possible to hold trench width to the minimum, at least to the top of the pipe. Sometimes sheeting can be reclaimed but good engineering practice recommends that sheeting be cut off above pipe level, leaving the lower portion in place. Because of the high cost of sheeting material, a metal cage is sometimes used to protect the workmen in the trench. At other times the trench is sloped in such a way as to prevent cave-ins. Under certain conditions, including soil formation, locations of buildings, streets, fences, general topographic features, etc., it is desirable to place the excavated material (spoil) as far as practical from the edge of the trench. This helps provide additional working space and the trench wall is less likely to shift, slide or cave in.

SOLID SHEETING BRACING

Backfilling The Trench

When backfilling the trench, only selected loose dirt, or granular material, free from rocks and large lumps, should be used. This material should first be placed under the pipe haunches and then in uniform layers of about 6" up each side until the backfill is at least 24" above the top of the pipe. As each layer is placed, it should be thoroughly compacted in such a manner as not to disturb the pipe. The rest of the backfill may then be placed by bulldozer or a bucket. Care should be taken to see that no large rocks, frozen chunks of earth, debris of spongy materials are used. The trench may then be flooded or jetted to compaction.

Manholes

Manholes are used as a means of access for inspection and cleaning. They are normally spaced 300 to 400 feet apart on smaller lines and at points of changes in direction, change in pipe size, and considerable change in grade. Large mains, 60 inches or more in diameter can be entered for inspection and therefore, require fewer manholes. Spacings on larger mains are usually 300 to 600 feet apart.

Service Connections

Service connections or house sewers should never be smaller than 4 inches in diameter. If a wye or a tee branch does not exist at the point where a connection is desired, use a conventional wye or tee saddle; the installation of a wye is considered best, however. Extreme care should be taken when tapping a sewer (1) to prevent breaking the pipe, (2) to insure that the saddle fits properly, and (3) to see that the saddle is properly cemented to the main line in order to prevent infiltration and root intrusion. Service connections

should never be made by breaking directly into the pipe. This makeshift method is never water tight and often causes serious problems later on. The use of a power driven tapping machine is highly recommended. A tapping machine will cut a round opening with smooth surfaces making a stronger more nearly water tight connection. Special attention should be given to residences (and other buildings) located at an elevation near the same elevation as the sewer main. Either backflow prevention devices or emergency overflow devices (or both) should be installed in the service connection lines. It is not unusual for the owner of the sewer system to be faced with an expensive lawsuit because of damage caused by sewage "backing" up into homes and commercial buildings. A qualified person should make a careful inspection of the service hookup before it is covered with backfill. Roof, driveway and foundation drains should never be connected to the service line. Adequate traps and vents should be in place and operable before a hook-up is completed. This will help prevent the entry of sewer gas into the building and may prevent a serious explosion. The service line itself should be inspected for defective joints uniform grade (where practical) and abrupt bends. All sewer pipes are more or less subject to clogging and a crooked line with abrupt bends is very difficult to "rod out".

Sewer Maintenance

Keeping the lines clean and unobstructed is the primary effort in good wastewater collection system maintenance. The complaints most frequently received about wastewater collection systems are caused by clogging and odors. A majority of the time a stopped or clogged line involves the removal of a temporary obstruction in the pipe; however, at other times it may involve

digging up and replacing several hundred feet of large pipe costing thousands of dollars. Up-to-date maps of the collection system are important in attaining good maintenance. They should show exact locations of manholes, directions of flow, grades, house sewers, etc. The value of a good preventive maintenance program cannot easily be overemphasized. Two very significant benefits are realized. First, the customer receives better service with less interruption, second it is better economy for the owner of the system because in the long haul, the cost of maintenance is generally much less than the cost of extensive repair or possibly replacement.

Root Intrusion Problems

Root removal is a big problem in some areas. Trees grow the year round. In the spring and summer the branches and leaves grow, and in the fall and winter the root system grows. Therefore, the most troublesome time with root intrusion is in the winter months. These roots are frequently removed by using flexible type rods with an auger-like cutter on the end. The root saw or cutter is rotated by twisting the rods either by power or manually as they are pushed into the sewers. Prevention of root intrusion is possible by the use of copper sulfate. By sprinkling about 2 pounds of copper sulfate crystals in the sewer channels of the manholes, root problems can be eliminated. In badly clogged sewers the dosage may have to be repeated, but after clearance is once obtained only annual application will be needed. The copper sulfate should not injure the trees. Normally, root problems start in the house sewer where flow is intermittent.

Generally, small lines need cleaning more often than large lines, and lines subject to root intrusion or grease build-up should be cleaned more often than

average lines.

Sewer Use Ordinances

All applications for industrial waste discharge into the collection system should be thoroughly evaluated and pre-treatment required where there is evidence to indicate the waste will be harmful in any way to the collection system or treatment plant.

Proper use of the sewage collection systems may be improved by enforcement of ordinances designed to protect the public and the operating agency. Some of the provisions that should be included in a sanitary ordinance are as follows:

1. Grease traps should be required in places where large amounts of grease will be wasted.
2. Sand traps should be required in wash racks or floor drains where sand and silt might enter the sewers.
3. Storm water should not be permitted to enter the sanitary sewer system.
4. Sewer lines should be laid in separate ditches at least 9 feet from a water supply line (6 feet vertically).
5. Pre-treatment of certain types of wastes, to be designated by the governing body, should be required.
6. Approved material and workmanship to prevent infiltration or health hazards should be required.

Other provisions necessary for the control of the sewage collection system may be included as necessary.

It is advisable to ask users to report any accidental discharge of liquid waste harmful to the collection system or treatment plant, so plant personnel can be prepared to handle the situation as best as possible. Tests can be conducted on the raw sewage to detect certain types of industrial wastes. If the waste is acidic in nature the pH test would be sufficient.

Gases in Sewers

Dangerous gases are present in wastewater collection systems and should be considered as a hazard to workmen. Two classes of gases could be present. One group includes carbon dioxide (CO_2), chlorine (Cl_2) and hydrogen sulfide (H_2S). This group may cause impairment of health or death from inhalation. The second group consists of gases which are inflammable or explosive under certain conditions. These include hydrogen sulfide (H_2S), gasoline vapor and methane (CH_4). Four conditions are necessary to create a gas explosion. They are (1) a combustible gas, (2) adequate supply of oxygen, (3) sufficient heat and (4) the proper mixing of gas and oxygen. Hydrogen sulfide will also cause corrosion in the system. This gas can readily be detected by its odor which smells like rotten eggs. Concentrations of 0.1 to 0.3 percent by volume may be fatal to workmen. When this odor is detected in any manhole or lift station, the area should be well ventilated and the operator should wear a gas mask that is equipped with life sustaining supply of oxygen.

Carbon dioxide (CO_2) in concentrations of 7 to 10 percent by volume may prove fatal, depending upon the physical condition of the worker. CO_2 is a difficult gas to detect without the use of testing equipment.

Methane gas is colorless, odorless, and tasteless. It will burn and forms

an explosive mixture when mixed with 5 to 15 percent of air.

Gas explosimeters or combustible gas indicators are available from several supply companies even in small pocket sizes. For information on these instruments write to: Mine Safety Appliance Company, Pittsburgh, Pennsylvania 15208.

Oxygen deficiency is a condition overlooked many times by sewer workers. When the ambient atmosphere contains less than 13% oxygen, it becomes extremely hazardous to men working under these conditions. Certain regulations require 18% oxygen concentration for safe working conditions and the worker to wear a canister type gas mask at this concentration. When the oxygen concentration is below 18%, the worker should wear a life sustaining mask of the type that furnishes an adequate supply of oxygen and/or air.

Sewer Outfalls

Proper installation and maintenance of the sewer outfall in lagoon operation is of extreme importance. When the sewer outfall empties into primary or secondary type treatment plants, many of the problems will have been solved. When such is the case, much of the floating debris will have been removed by the bar screen, and grease, feathers, and similar material will float to the surface in the primary settling basin where it will be skimmed off and disposed of. Also, much of the grit will be settled out in the chamber designed for such removal.

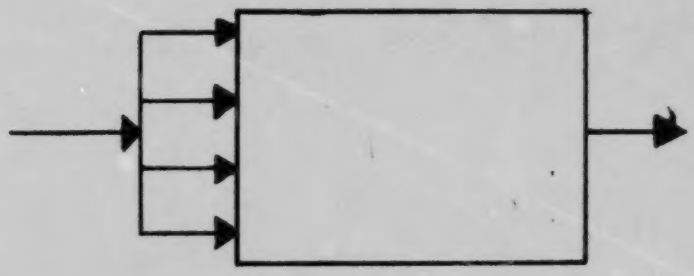
When the sewer outfall carries raw sewage directly to the lagoon, provisions should be made to remove as much of the aforementioned debris as possible prior to the sewage entering the lagoon. In some instances bar screens are installed in appropriate lift stations and this will assist in removing sticks, rags

NO SPARKS OR FLAMES WHERE THE POSSIBILITY OF EXPLOSIVE SEWER GAS EXISTS

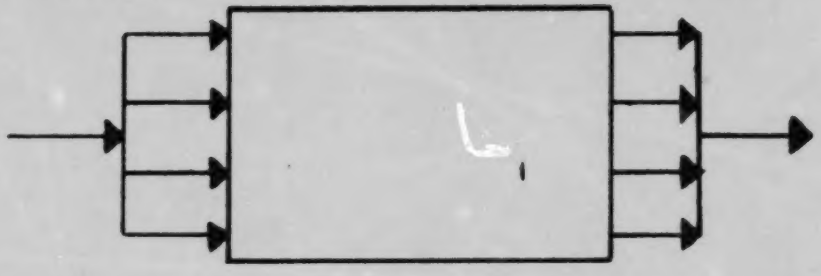
and other debris that would float to the surface of the lagoon. When such devices are used, it is imperative that the bar screens be cleaned at proper intervals to prevent a stoppage of the flow and a backup in the sewer lines. If none of the above-mentioned methods of removal are available, the material that enters the lagoon and floats to the surface will have to be hand skimmed periodically. This is a time consuming and costly method and these conditions should be avoided if at all possible.

Sewer outfall designs will be dealt with in later chapters, but it is proper to mention at this point that the introduction of sewage into a lagoon is not always a single entry system. Various designs have been used and are illustrated by the following drawings:

SINGLE ENTRY
AND SINGLE EXIT



MULTIPLE ENTRY
AND SINGLE EXIT



MULTIPLE ENTRY AND MULTIPLE EXIT

Multiple entry systems are used to provide better distribution of the influent. It is essential that the B.O.D. (organic loading) be applied as evenly as possible to all areas of the lagoon. If this is not accomplished, certain areas may receive so much of the organic loading that these areas will become septic and cause many problems.

When more than one lagoon is to receive the raw wastewater, an arrangement can be made whereby the flow enters a basin from which the sewage flow to the lagoons is controlled by either pipe sizing or valve control. If both lagoons are of equal size or capacity, the flow, of course, would generally be the same to both. When lagoon size and capacity differ, the amount of sewage each is to receive can be controlled in the basin which is sometimes referred to as a splitter-box. This type of loading is referred to as parallel loading.

Series loading in a lagoon system occurs when all of the wastewater is introduced into a single lagoon and then the effluent from this lagoon is channeled through one or more lagoons where it receives additional treatment. Sizing and loadings for this type system will be dealt with in a following chapter.

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

Name_____ Date_____

Class_____ Grade_____

Completely mark out the letter corresponding to the correct answer.

1.	A	B	C	D	E	18.	A	B	C	D
2.	A	B	C	D		19.	A	B	C	
3.	A	B	C	D	E	20.	A	B	C	
4.	A	B	C	D		21.	A	B	C	
5.	A	B	C	D		22.	A	B	C	D
6.	A	B	C	D	E	23.	A	B	C	
7.	A	B	C	D	E	24.	A	B	C	
8.	A	B	C	D	E	25.	A	B	C	
9.	A	B	C	D		26.	A	B	C	
10.	A	B	C	D		27.	A	B	C	
11.	A	B	C	D						
12.	A	B	C	D						
13.	A	B								
14.	A	B	C	D						
15.	A	B	C							
16.	A	B	C							
17.	A	B	C							

EXAMINATION QUESTIONS

WASTEWATER COLLECTION SYSTEMS

Read each question carefully. Circle the letter for the corresponding correct answer. If you are uncertain about which answer is correct it is recommended that you look up the answer in Chapter I, Wastewater Collection Systems. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign, and mail to the Water and Wastewater Technical School.

1. Water lines and sewers should not be laid in the same trench because of the possibility of contaminating the water. The recommended minimum horizontal distance between water lines and sewers is:

   a. Nine feet
   b. One foot
   c. Twenty-five feet
   d. Fifty feet
   e. More than fifty feet

2. Wastes are treated to:

   a. Prevent pollution
   b. Protect human health
   c. Remove harmful wastes from sewage
   d. All of these

3. A map showing where sewers are laid, location of manholes, connections, etc., is necessary because:

   a. The home owners require it
   b. It aids in finding lines when stoppages occur
   c. The fire department needs the maps
   d. The chief of police requires the maps
   e. It would create a new job

4. A common tool used today to clean out sanitary sewers is a:

   a. Fork
   b. Shovel
   c. Rodding machine
   d. Power drill

5. A separate sewer system is a system in which:

   a. The business section of the town has special type sewers
   b. Sewers are laid 10 or more feet from water mains
   c. The sewers are paid for by special assessments
   d. Storm water is carried in a system other than that carrying domestic sewage

6. When sewage is delayed in the lines by means of flat grades or long lines, the dissolved oxygen is used up. What form of decomposition then takes place in the lines?

   a. Aerobic
   b. Colloidal
   c. Anaerobic
   d. 2-stage digestion
   e. Ozone

7. Hydrogen sulfide gas is not only a poisonous gas but also it will cause one of the following to happen in a system:

   a. Corrosion in the system
   b. Stoppages in lines
   c. Vapor locks in lines
   d. Lowering of chlorine demand
   e. A protective coating to be formed in the lines

8. One of the best methods for the control of hydrogen sulfide production and resulting odors in long sluggish flowing sewers is:

   a. Addition of $CuSO_4$
   b. Chlorination
   c. Addition of lime
   d. Ventilation
   e. Flushing the sewers

9. Cigarettes, pipes, and other sources of fire, when used down in manholes, deep pumping station structures, digester control chambers, or other poorly ventilated structures:

   a. Will provide a good way to test for inflammable gasses
   b. Have actually caused serious and in some cases fatal explosions
   c. Are theoretically unsafe but have never been known to cause an explosion
   d. Have no significance as sewer gas does not burn under any condition

10. Sewage treatment is essential to (more than one answer is correct; mark out each correct answer):

a. Control odors at the end of the sewer
b. Produce a good fertilizer
c. Conserve natural resources and protect health
d. Stop the growth of weeds in the receiving stream

11. If you are informed that a large quantity of acid waste was accidentally discharged to the sanitary sewer in your city, you could determine when it reached the plant because:

a. The dissolved oxygen in the raw sewage would exceed the saturation value
b. The pH of the raw sewage would rise
c. The pH of the raw sewage would be lowered
d. The volatile portion of the suspended solids would be greatly increased

12. Traffic may be warned of a job in a street or other traffic area by:

a. High-level signs and flags far enough ahead of the job to adequately alert drivers
b. Traffic cones arranged to guide traffic around work area
c. A flagman directing traffic
d. All of the above

13. The presence of methane gas can be detected by smell.

a. True
b. False

14. The bell end of a bell and spigot pipe should always be laid:

a. With the bell pointing up-grade
b. With the bell pointing down-grade
c. This type of pipe should not be used
d. It makes no difference where the bell is located

15. Which one of the following gases is combustible?

a. H_2S (Hydrogen sulfide)
b. CO_2 (Carbon dioxide)
c. Cl_2 (Chlorine)

16. In the absence of oxygen, combustible gases can:

a. Never explode
b. Sometimes explode
c. Always explode

17. One of the best controls in preventing odors from developing in the collection system is to:

    a. Keep the lines full at all times
    b. Slow down the flow so as to prevent the odor from being forced out the vents on buildings
    c. Ensure a minimum flow of two feet per second throughout the entire system

18. Air consists of several gases of which nitrogen and oxygen are the principal ones. Air is considered dangerous to breathe when the volume of oxygen it contains drops below:

    a. 13%
    b. 22%
    c. 44%
    d. 18%

19. H_2S in sewer lines may be detected by the following test:

    a. Paper torch test
    b. Orthotolidine test
    c. Filter paper soaked in a lead acetate solution

20. Root growth in sewer lines may be controlled to some extent when properly treated with:

    a. Ammonium nitrate
    b. Copper sulfate
    c. Calcium carbonate

21. Odors resulting from septic wastewater in the collection system can be reduced by:

    a. Adding soda ash
    b. Adding chlorine
    c. Adding copper sulfate

22. The best type of joint to prevent infiltration is:

    a. Bituminous
    b. Epoxy
    c. Plastic or rubber
    d. Cement

23. House sewers should be laid on a grade of at least:

    a. $\frac{1}{4}$ inch per foot
    b. 2 inches per 100 feet
    c. 1 foot per 100 foot of line

24. The spacing of manholes on laterals is normally:

a. Not important
b. 300 to 400 feet apart
c. 800 to 1000 feet apart

25. The recommended method of backfilling is:

a. Not important
b. To be done by hand for the first 2 feet above the sewer line
c. To be left loose in order to prevent breaking the line

26. Of the various methods used to connect building sewers to public sewage lines, the one considered the best is to:

a. Install a wye
b. Use a tee saddle
c. Use a wye saddle

27. Ditches cut in clay soils:

a. Never need shoring
b. Always need shoring
c. Need shoring under certain conditions

CHAPTER II

SEWAGE LIFT STATIONS AND PUMPING EQUIPMENT

CHAPTER II

SEWAGE LIFT STATIONS AND PUMPING EQUIPMENT

General Design of Lift Stations

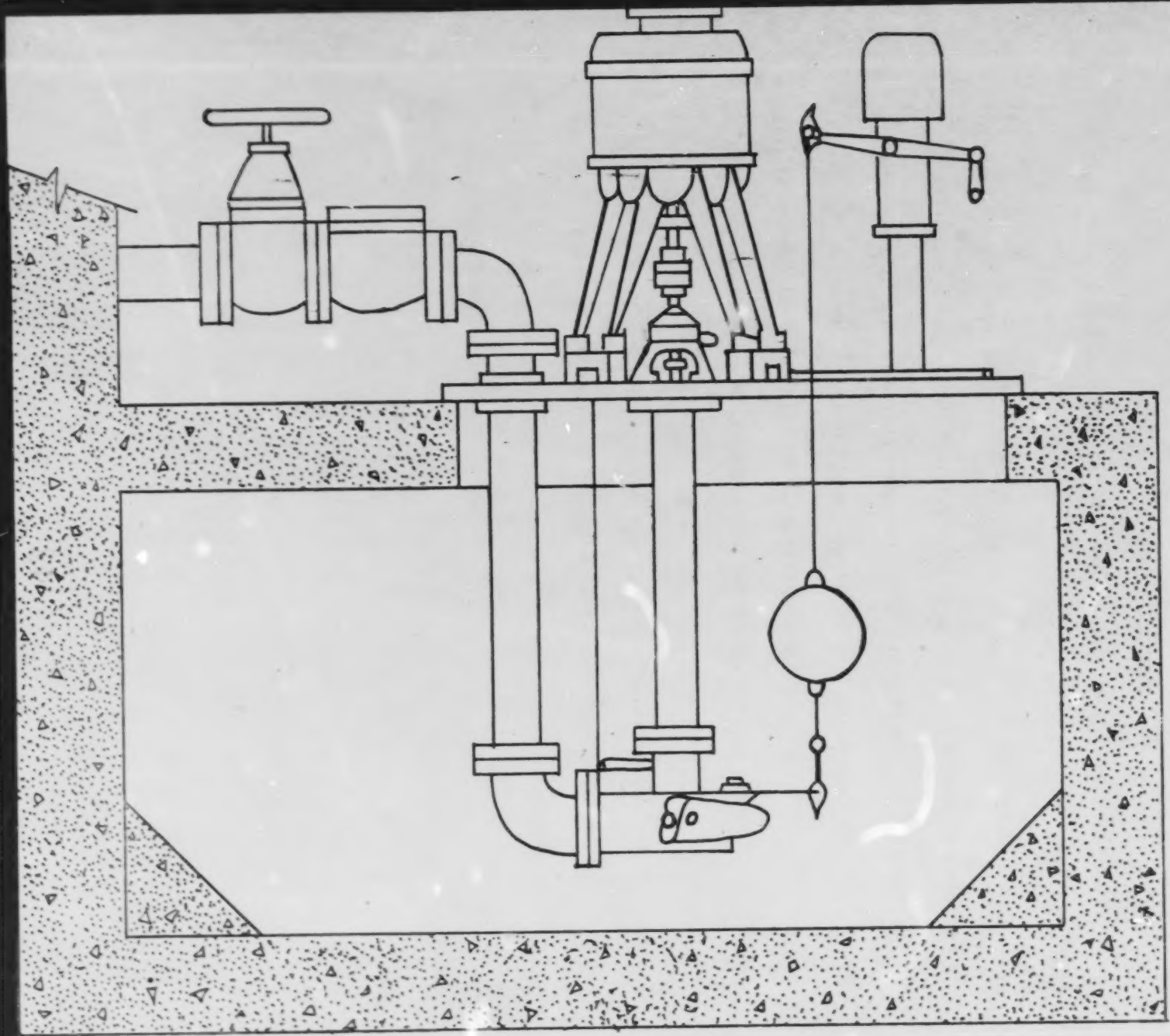
Lift stations are usually classified into two general types --wet-well lift stations and dry-well lift stations.

Wet-well lift stations consist of (1) a small holding reservoir or sump to receive and hold the sewage until it is pumped, (2) a pump or pumps to lift the sewage, (3) an electric motor or other prime mover to power the pumps, (4) the necessary piping, valves, and fittings to convey the sewage to the pump and then to the point of release, and (5) a control system to start and stop the prime mover to maintain the maximum and minimum levels in the wet-well.

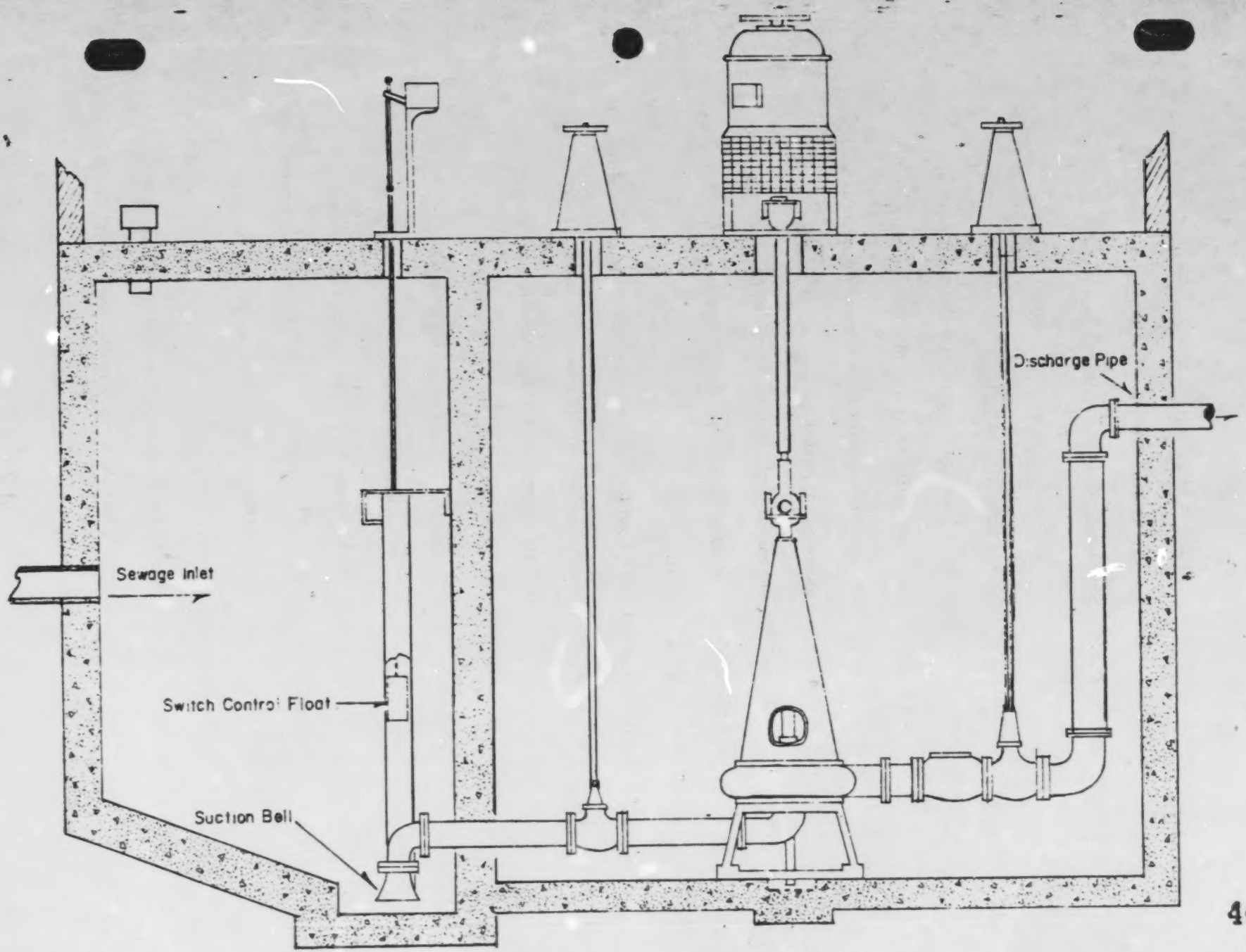
Generally, the wet-well type of pump station is designed for flows in the lower range and can usually be constructed at lower cost. There are some advantages and disadvantages in all types of pump stations; no one system has all the good features,neither do the other types have all the bad features. The consulting engineer will consider all factors involved and then recommend the type most nearly adapted to give efficient performance at a given location.

Dry-Well Lift Station

Dry-Well lift stations consist of two pits or wells; wet-well and dry-well. The wet-well receives and holds the sewage and the dry-well houses the pumps, motor, piping, valves, fittings and electrical controls.



WETWELL PUMP STATION II-2



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A DRY WELL LIFT STATION

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The advantages of the dry-well lift stations are (1) the pumps are easily accessible for inspection and servicing and (2) the pumps may be installed below the sewage level in the wet-well, thus minimizing pump priming difficulties.

Factory Built or Package Lift Station

There are several "factory-built" or "packaged" lift stations on the market. Most of these units are of metallic construction designed for underground installation. The dry-well of these stations is furnished complete in one package, and it is only necessary to connect up the pump suction lines, the discharge force main, and the electrical service for it to be in operation.

Wet-wells should be equipped with hopper bottoms to prevent the formation of sludge banks in the wet-well.

Adequate ventilation should be provided to the wet-well to avoid building up excessive air pressure or vacuums above the sewage in the wet-well as the sewage level rises or falls. Adequate ventilation also prevents the accumulation of explosive and lethal gases in the wet-well.

Ideally, the lift station would pump the inflowing sewage at the same rate at which it flows into the wet-well. This would maintain the sewage in as fresh a condition as possible and would, therefore, minimize odor nuisances and facilitate treatment of the sewage. If for any reason it becomes necessary to by-pass raw sewage to a receiving stream without treatment, it must be reported to the state regulatory agency.

The capacity of the wet-well should be such that the sewage will not be retained so long that it starts to become septic. Probably under no circumstances should the sewage be retained in the wet-well longer than thirty minutes and

a shorter retention time than this is desirable. The capacity of the wet-well should also be such that too frequent on-off cycling is avoided. A ten-minute or more operating period of each pump is desirable.

A manhole or other means of entrance must be provided in wet-wells. These manholes or entrance covers should be of substantial construction and equipped with a good locking device. All entrance covers should be locked at all times except when an authorized employee is working or making an inspection. Where grates are installed for ventilation or inspection, these must be maintained in good condition, securely fastened in place or locked at all times except when the operator is present.

Many wet-wells are equipped with a trash collection basket through which the influent must flow. Larger pieces of wastewater debris (or solids) are the liquid portion and smaller pieces of solids are allowed to pass through the meshes of the basket into the wet-well. This basket screening device provides good protection against pump clogging or possibly serious damage to the pump. Usually, a substantial hoist is used to raise and lower the basket when the contents are to be removed for disposal by burial, incineration or other approved methods of disposal. The "hatch cover" through which the basket is raised or lowered must be substantial and locked except while in use. Some wet-wells are equipped with bar screens (bar racks) which must be cleaned at regular intervals. Steps with hand railings or dependable ladders should be provided for the safe entry and departure of workers. All wet-wells, unless properly ventilated, are potential hazards. Any of the various types of sewer gas may collect and remain in the wet-wells. Slipping and falling are also hazards encountered in wet-well maintenance and operation.

Pneumatic Ejector

The pneumatic (air) ejector operates by displacing the sewage that has accumulated in the receiving pot with compressed air, thus forcing the sewage through the force main to the point of release. When these units are used in place of pumps in a sewage lift station, the flow is usually from a wet-well to the receiving pot.

Pneumatic ejector pump lift stations may be equipped with one or more pots (ejector tanks) and in tank capacities ranging from small to very large, depending on the amount of wastewater to be pumped at that location.

In addition to piping for wastewater inflow and discharge, check valves which are required in both the inflow and discharge lines. Gates valves are necessary in both the inflow and discharge lines in order to isolate the pots and check valves for maintenance and repair. A sensing device for air control is necessary in order that air pressure be applied for expelling the wastewater from the tank into the pressure line and for stopping the flow of air to the pot, exhausting the air from the pot and allowing wastewater to again flow into the tank. In addition to this one or more air compressors and motors must be installed and usually an air storage tank. To provide for emergencies it is best to have one spare compressor and motor ready for immediate use.

Lift Station Pumps

Sewage differs from water in at least three ways. (1) physically, because of floating and suspended material, (2) biologically, because of organic waste, and (3) chemically, because of organic and mineral waste in solution. These differences make the use of specially designed pumps necessary for pumping sewage.

The most important characteristics of a sewage pump should be reliability and freedom from clogging. An interruption of service may cause sewage to flood the lift station, or some other undesirable occurence.

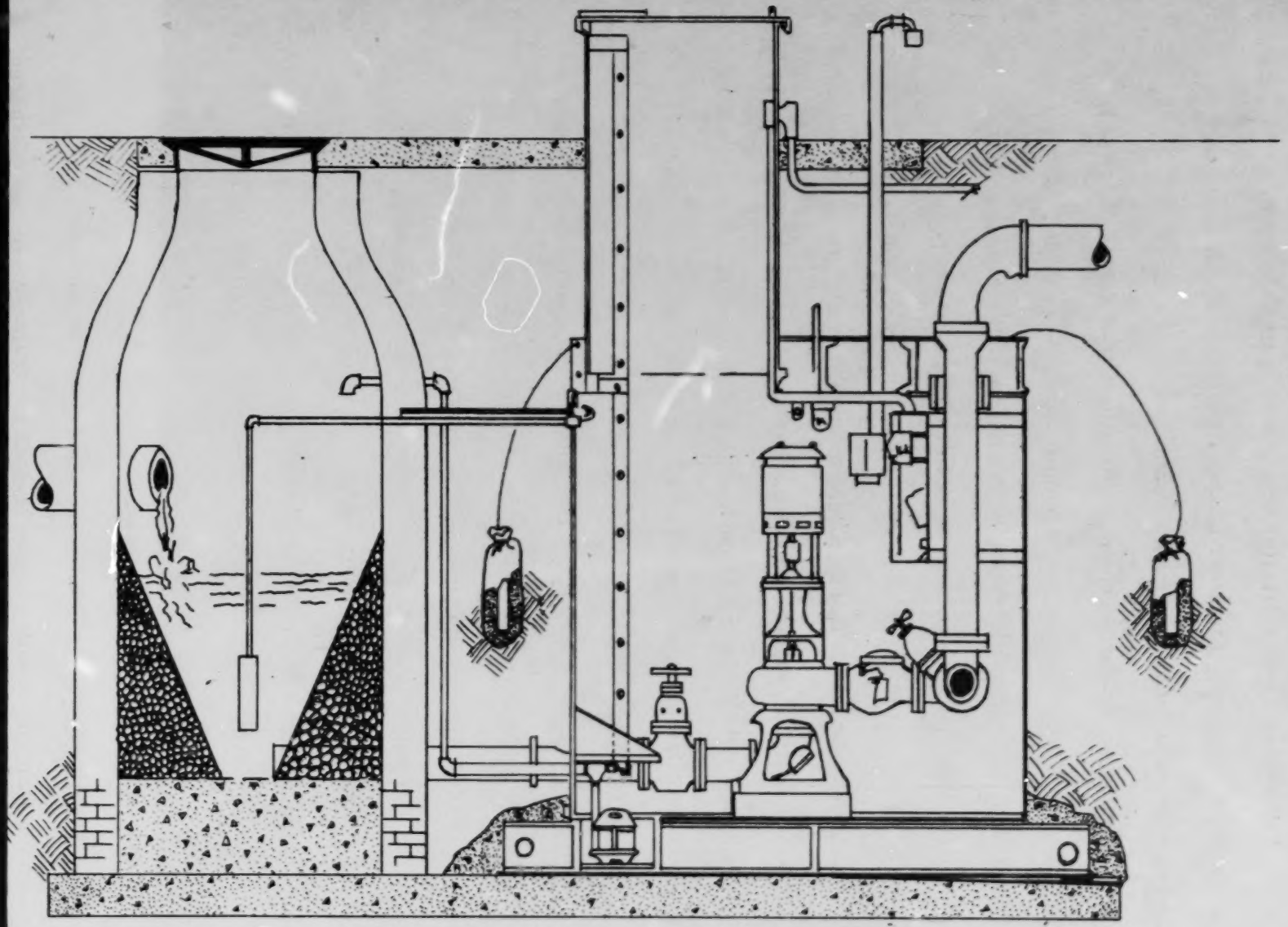
Some recommendations concerning the installation of pumps for lift use:

1. Duplicate Units - Two or more pumps should be provided. If only two units are provided, they should have the same capacity. Each should be capable of handling flows in excess of the expected maximum flow. It is best to adjust the controls, so that the pumps alternate in operation and operate together during periods of high flow. Where three or more pumps are provided, they should be designed to fit actual flow conditions and of such capacity that, with any one pump out of service, the remaining pumps will have the capacity to handle maximum sewage flows.

2. Protection Against Clogging - The pumps employed at the lift station should be of the non-clog type. That is, solids $2\frac{1}{2}$ inches in diameter can pass through the impeller without stopping it up. The bore through a standard water closet is $2\frac{1}{2}$ inches in diameter, therefore, anything flushed through a water closet could be handled by the pump.

3. Pumping Rates - The pumps and controls of main pumping stations should be selected to operate at varying delivery rates to permit discharging sewage from the station to the treatment works at approximately its rate of delivery to the pump station.

4. Dry-Well Dewatering - The floor in a dry-well should slope to a sump where a sump pump will remove leakage or drainage with the discharge above the overflow level of the wet-well. The accumulation of sewage



PACKAGED UNDERGROUND PUMP LIFT STATION

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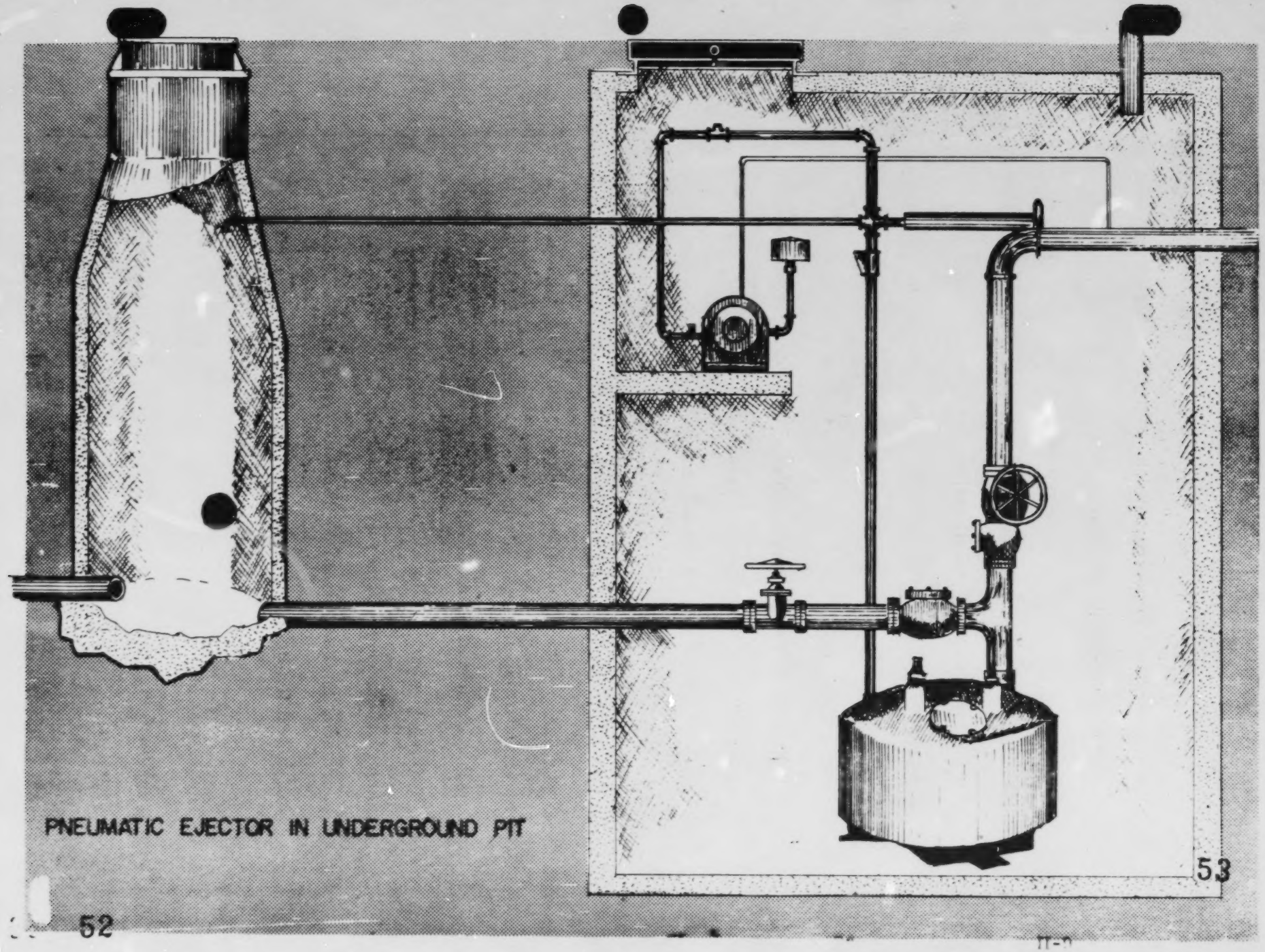


PNEUMATIC EJECTOR IN UNDERGROUND PIT

in the dry-well shows poor maintenance, may cause odors, accidents, or damage and should be prevented.

5. Electrical Fixtures - In enclosed places where gases may accumulate, installation of electrical fixtures shall comply with the National Board of Fire Underwriters' specifications for hazardous conditions.

6. Pipe Supports - The weight of the piping, valves, and fittings should not be supported by the pump casing, but by pipe hangers, pedestals, thrust-blocks, etc.

7. Foundations - The pump and motor foundation should be of adequate strength and rigidity to avoid displacement during pump operation.

8. Rotation - When a centrifugal pump is installed, the rotation should always be checked. Most pumps will actually pump small amounts of liquid when rotating in the wrong direction.

9. Couplings - The coupling that connects the pump shaft to the prime mover shaft should be so adjusted as to bring these two shafts into proper alignment. This is true even with flexible couplings.

10. Humidity Control - Electrical controls are subject to considerable damage if exposed to excessive moisture. Not only is there life shortened, the controls do not function properly after corrosion sets in. In addition to this, other metal parts oxidize more rapidly. Condensed moisture dripping from and clinging to the many different surfaces gradually cause damage and are unsightly. Humidity control equipment properly operated and maintained will relieve this condition. Generally, humidity control equipment is "built-in" standard equipment in the factory built "packaged" pump station.

11. Standby Power - Holding Basins - Emergencies may occur at any time and put a pump station out of service. Power failures are more common than some of the other emergencies. If these interruptions are of considerable duration it will result in the discharge of improperly treated wastewater which is in violation of operating permit conditions. In some cases, electrical power is available from more than one source by means of "two-way feed lines." At other installations, auxiliary power is available by means of a combustion engine powered generator. The generator may be either stationary or portable. A portable gasoline powered standby pump can also be used during such emergencies. At some locations holding basins have been constructed that will retain as much as 6 or 8 hours normal flow. After service is restored the contents of the holding basin flow into the wet-well as pumping capacity permits or may be held in the basin until periods of low flows. Obviously, there is no way to be prepared for all emergencies but, standby power and holding basins have proven to be of great value at many locations.

12. Spare Parts - A considerable amount of "down time" can be avoided by carrying a reasonable stock of spare parts that are known to be subject to frequent failure. These may include some types of bearings, seals, filters, and packings. The manufacturers recommendations and your own experience are the best guides for stocking spare parts. Parts are expensive; therefore, a surplus stock "ties up" money that may be needed for other equally important uses.

Centrifugal Pumps

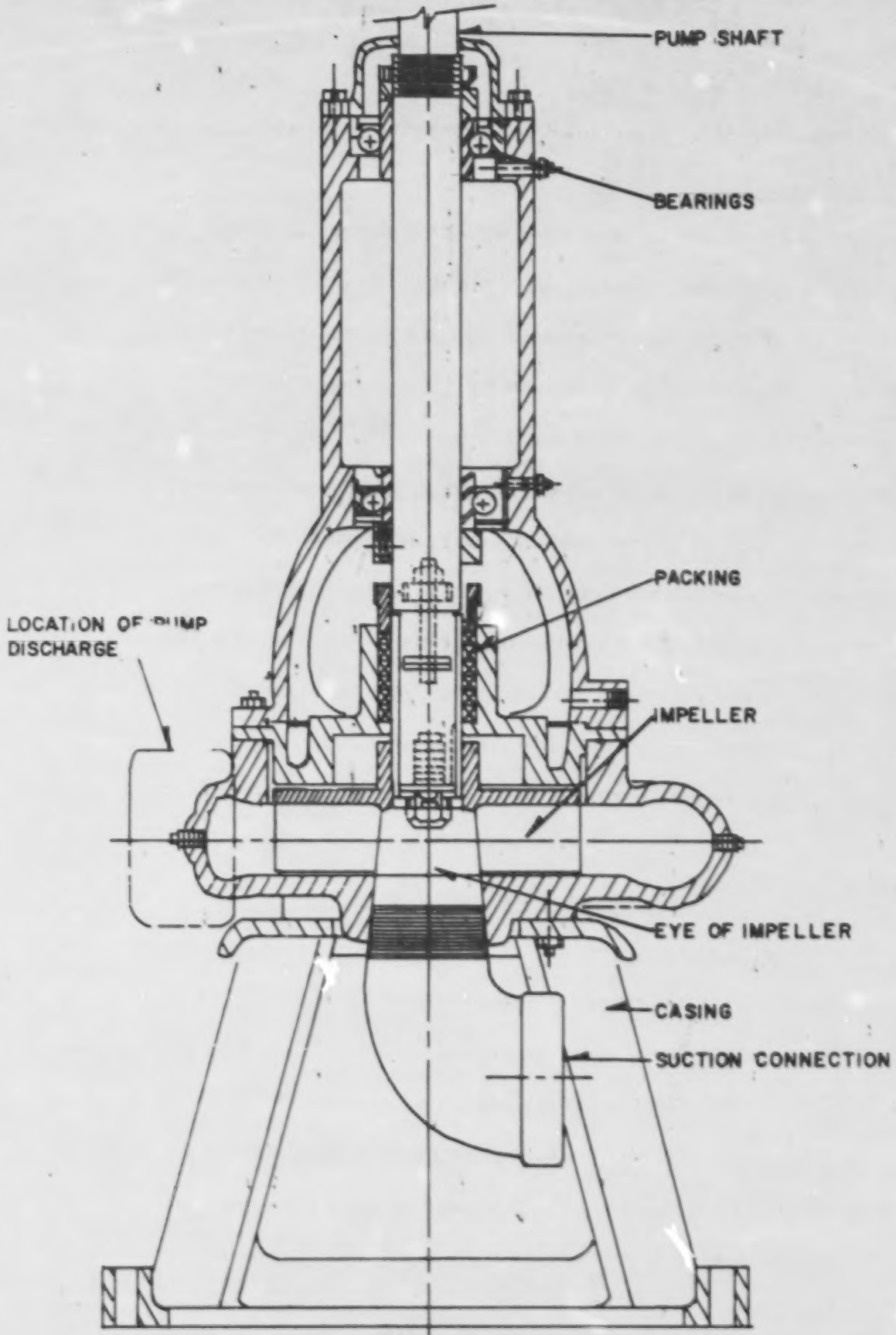
Centrifugal pumps have practically replaced all other types of pumps used for pumping raw sewage. Reciprocating and rotary pumps are not adapted to sewage pumping.

Centrifugal pumps are described in various ways. The pump size is described as the diameter of the discharge connection. Some pumps have a larger suction than discharge connection. Pumps with vertical shafts are called vertical pumps; and pumps with horizontal shafts are called horizontal pumps. Close-coupled pumps are designed so that the motor and the pump are constructed on the same shaft. Extended shaft pumps must have a coupling to connect the motor shaft to the pump shaft.

Sometimes a centrifugal pump is described by the characteristics of the impellers. A non-clog impeller is usually chosen for centrifugal sewage pumps.

Screw Pumps

Although screw type pumps are among the older types of successful mechanical pumps, their use has not been as common or as wide spread as the use of the centrifugal pump in the field of wastewater. Although the screw pump is not ordinarily designed to pump wastewater into a pressure main it is extensively used to raise wastewater from a low level to where gravity flow is feasible. The screw pump is simple to operate, requires minimal attention and maintenance, will operate from zero flow to full capacity without automatic controls or manual adjustment. This pump operates at a low rate of speed (RPM's), is sturdy and is not easily damaged. A "dry run" for an extended period of time will not damage it. The proper application



VERTICAL SINGLE, SUCTION PUMP

of this pump should be determined by the manufacturer and a qualified engineer.

Air Lift Pumps

This device should not be associated with the "pneumatic ejector" because each operates in a different manner. The "air lift" is most commonly used to transfer either sludge or supernatant from one compartment to another compartment of an extended aeration (activated sludge process) treatment plant, especially the factory built "Packaged" plant. The "air lift" is limited to very low range of lift and is not capable of pumping into a pressure main under any practical amount of pressure, however, it is sometimes used to lift wastewater to a level where gravity flow takes over. Generally, its use in the collection system is not significant because of its limited lifting capacity and the cost of the air supply necessary per foot-pound of lift. This lift has useful applications, costs very little, requires minimal maintenance, but its power requirements in proportion to its pumping capacity restrict its application.

Extended Shaft Centrifugal Pump

The centrifugal pump consists of five principal parts: (1) housing or casing; (2) pump shaft, (3) bearings, (4) impellers and (5) packing.

All centrifugal pumps have two or more bearings carrying the shaft load. The impeller rotates within the enclosing casing and gives to the water or sewage a high velocity, and the casing converts this velocity to pressure, as well as conducts the flows to and from the impeller. The function of the packing or mechanical seal is to prevent air from being sucked into the pump or the liquid leaking out.

Maintenance of Pumps

A centrifugal pump has relatively few moving parts; basically, only the shaft, impeller and bearings move.

The impeller, itself, needs little maintenance. However, it should be removed from the pump occasionally and checked for wear and scaling or deposits.

The pump shaft passes through a stuffing box; then it extends through the pump casing. The packing rings should be replaced when they become worn or hard. The practice of placing new packing rings over worn packing rings is to be avoided. The rings should be staggered so that the cut ends do not coincide. The packing should be adjusted moderately tight and still allow an occasional drip of water to lubricate between packing and shaft. The shaft sleeve should be examined occasionally to see that it is not badly scored; if it is, it should be replaced. If the pump is provided with a mechanical seal instead of the conventional packing, the purpose is the same and it should be replaced when it starts leaking.

The bearings are of one of two types--either sleeve bearings or anti-friction bearings, such as roller or ball bearings. The lubrication of these two types of bearings is entirely different. The sleeve type bearing cannot easily be over-greased; however, it is quite easy to over-grease the anti-friction bearing. It is best to follow the manufacturer's instructions on lubricating pumps, as they know what is best for their machinery. Excessive lubrication can distort a bearing, destroy the seals, and cause excessive heat all of which will, at best, shorten the life of a bearing. The worst effect is that excessive heat and vibration may cause the bearing to fail immediately. Usually, a

bearing failure starts a "chain reaction" which results in damage to one or more other bearings. To emphasize previous instructions, this repetition is justified. Follow the manufacturer's recommendations as to quality and quantity of lubricant, frequency of lubrication and the method by which the lubricant is applied. These recommendations are very important, will extend the useful life of equipment, maintain its efficiency and hold down time and operating costs at a minimum.

Piping and Valving

The general functions of piping and valving are the same at all lift stations. These functions are: (1) to route the sewage being pumped to the pump impeller and then to the desired destination; (2) to be able to isolate a pump, with the proper arrangement of gate valves, so it can be serviced without interrupting the functioning of the remainder of the station; (3) to prevent, by the use of check valves, backflow of sewage through idle pumps; and (4) in some cases, to allow back-flushing one pump with another, to dislodge objects stopping or plugging the piping or impeller. Piping should be of such size that an average flow of two feet per second velocity is maintained to prevent solids from accumulating.

Electric Motors

Centrifugal pumps at fixed locations such as lift stations must be powered by a prime mover. Almost universally, electric motors are used for this job.

Alternating current (A. C.) electrical motors are available in three different types: (1) squirrel cage motors, (2) wound-rotor or "slip ring" motors, and (3) synchronous motors. The squirrel cage and synchronous

motors are constant speed machines, while the wound-rotor motor is a variable speed machine. It is more common to see squirrel cage motors used up to around 200 horsepower where constant speed motors are employed. The variable speed wound-rotor motor is sometimes utilized at stations in an effort to match the pumping with the incoming sewage.

Electrical Systems

Three phase power is a must for lift stations if top effiency is to be obtained. These stations are normally powered by 220 or 440 volt systems.

Suitable fuses and/or circuit breakers should be provided to protect the electrical system and apparatus. All wiring should comply with the National Electrical Safety Code.

Occasionally, a situation might exist where all of the three phase motors will fail to operate. The lights and other single phase equipment may or may not function. This condition may be the result of losing one leg of the three phase power supply.

Motor starters should not be blocked shut. Any malfunction should be found and corrected.

Safety devices should be used to minimize the possibilities of accidents. Great caution should be used in changing fuses, testing circuits, etc., around lift stations, as the voltages normally employed are dangerous. Insulated floor mats, insulated gloves, fuse pullers and other safety devices should be used to the fullest possible extent to protect the operator from accidental shocks and possible injuries.

An electric motor and the area around it should be kept clean; this is particularly true of open motors.

Automatic Controls

Most of the automatic controls used for lift stations fall into one of three categories: (1) pressure controls, (2) float controls, (3) probe or electrode controls. All of these will perform satisfactorily if properly installed and maintained. However, much attention should be given to the selection of the controls which start and stop the electric motor that powers the various pumps at the lift station as the controls which start and stop the electric motor that powers the various pumps at the lift station are the brains of that station.

The forementioned categories of start and stop controls or sensing devices may be briefly described as follows:

A. Electrode or probe type device which upon contact or break of contact with the wastewater in the wet-well, activates the automatic electric controls that start and stop the sewage pumps.

B. Conventional float type device, consisting of a float attached to a rod, chain cable or tape. The float moves up or down as the liquid rises or falls in the wet-well either opening or closing the contact points on the start-stop (on-off) controls.

C. Tilting float with mercury switch "built in". The floats are attached to and suspended by a water-proof electrical cable. As the liquid level rises or falls the floats either tilt or hang upright, thereby opening or closing the contact points in the mercury tubes, which in turn start or stop the pumps.

D. Pressure type sensors may be either a pipe or tube with one end submerged in the wet-well liquid. The other end diaphragm which activates the electrical controls. The most extensively used pressure

type sensing device requires a small compact air compressor, motor and air storage tank. A small amount of air is constantly discharged to the bubbler pipe and on into the wet-well contents. As the liquid level in the wet-well rises, more pressure is applied to the diaphragm at the other end of the "bubbler" line. As the level drops, less pressure is applied. This pressure differential is a means of starting and stopping the pumps at the desired wet-well liquid levels.

E. "Flow matching" pumping equipment is coming into more common use and is producing satisfactory results at locations where "flow matching" equipment would have been considered impractical a few years ago. Generally a variable speed motor of sufficient horsepower is connected to a pump with adequate capacity to handle the average daily peak flows. With normal flows the wet-well level is maintained at a fairly constant level. When the flow into the wet-well increases or decreases, the pump speed is proportionately increased or decreased by means of automatic flow matching controls. At such times that the flow into the wet-well exceeds the capacity of the flow matching pumping equipment, another pump, usually a conventional constant speed pump is activated and operates until the water is lowered to the desired level. The initial cost of flow matching pump equipment is usually greater than for conventional equipment. However, the consulting engineer is qualified to decide which type of control equipment is best for a certain location.

All types of controls are well designed and usually give good service but maintenance is required and should be performed according to the manufacturers instructions. The "Operation and Maintenance" manual provided by the consulting engineer also provides excellent information and should be utilized to the fullest extent. General maintenance is extensively discussed in another chapter of this manual.

Pump Operations

As most lift stations are automatically controlled, operation consists primarily of inspections and preventive maintenance. Careful attention should be given to determining the causes of excessive vibration and unusual noises. Ignoring these problems usually leads to premature breakdown and excessive repair bills.

The operator will encounter many operational problems with sewage pumps from time to time; however, if he will attempt to visualize the functions of the various pumps, valves, piping and controls, the causes of these problems will usually explain themselves.

The operator should always make sure that the pump is full of liquid before starting a pump. If a pump is started dry it will not lubricate the packing and wearing rings or in some pumps a bearing or sleeve.

Pump Characteristic Curve

When a pump or pumps have been installed in a pumping station, the manufacturer of that pumping equipment will furnish to the buyer a pump characteristic curve showing head, gallons per minute, brake horsepower, and percent efficiency, with one pump running or more than one pump running at the same time.

When two or more pumps discharging into the same header are operated at the same time, they are said to be in parallel. Their combined capacity in gallons per minute is not the sum of their individual capacities.

Appurtenances

The minimum appurtenances required at even the most remote lift station are adequate lighting for night inspection and repairs, adequate drainage from pump glands and adequate housing or fencing to protect the installation from vandals and other unauthorized persons. All entry ways such as gates, doors, hatch covers, etc. should be kept locked. Switch boxes and control panel covers installed outside the station must be locked. In addition to helping prevent vandalism and theft, safety will be provided for curious children and careless adults. Lift stations should also have properly drained floors.

Dry-well installations and wet-well installations with a building over the wet-well should be equipped with a forced draft ventilation system capable of six air turnovers per hour when operated continuously. With intermittent operation, a two-minute turnover is recommended.

In any case, the appurtenances should add to the ease of the operation and maintenance of the station, and to the safety and convenience of the operator.

A source of water should be provided for cleaning floors, walls, flushing and cleaning wet-wells and for general cleaning purposes during equipment repair. A water supply under pressure is almost a must in case of spills and overflows. Maintenance personnel need a water supply for washing hands, rubber gloves and footwear.

Appearance

Regardless of the exterior design, the station should be maintained to present the best possible appearance to the public. "Good housekeeping" at the pump station is just as important as it is at the treatment facility. Painting, general building repair, walkway and driveway maintenance, removal of rubbish and mowing are all an important part of improving pump station appearances. Shrubbery and flowers if time and funds permit, will add greatly to the appearance of the station.

SLUDGE PUMPS

Sludge is more viscous or thicker than water or sewage. The solids content of sludge runs about 5% in primary tank sludge, and about 10 to 15% in digested sludge.

Most sludge pumping installations use reciprocating pumps of the plunger type. They are quite durable and give good service if properly adjusted and lubricated. They consist essentially of a cylinder and piston arrangement. In some designs, the plunger or piston is connected by a rod to a crank shaft. Either a single plunger or several may be connected to the same crank shaft. The length of stroke is fixed in this design. In other designs, the connecting rod is connected to an eccentric on a shaft instead of a simple crank shaft. The length of the stroke on this type pump can be varied by changing the degree of eccentricity.

In some pumps metal flap valves are used; in others, a ball valve is used. It is a good plan to provide a relief valve in connection with reciprocating pumps to protect the pump should the discharge line become clogged. A positive displacement pump should never be started against a closed valve because it may damage the pump or piping.

In sludge pumping, care should be exercised to keep from breaking the sludge blanket or top layer. Otherwise, a hole will have formed through the sludge and the pump will pick up sewage or supernatnat liquor instead of sludge. This situation can best be prevented by pumping sludge at a rate of between 60 and 80 gallons per minute.

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C D
2. A B C
3. A B C D E
4. A B C D
5. A B C D E
6. A B C D
7. A B C D
8. A B C D E
9. A B C D E
10. A B C D
11. A B C
12. A B C
13. A B
14. A B
15. A B

EXAMINATION QUESTIONS

Sewage Lift Stations and Pumping Equipment

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter II, Sewage Lift Stations and Pumping Equipment. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. If, for any reason, it is necessary to bypass raw wastewater to a receiving stream without treatment, it must be:

   a. Done at night.
   b. Cleared through the City Council.
   c. Reported to the State Regulatory Agency.
   d. While the certified operator is not there.

2. Maintenance of couplings between the driving and driven elements includes:

   a. Keeping proper alignment even with flexible couplings.
   b. Keeping the electrodes free of scum.
   c. None of these.

3. The most important characteristics of a sewage pump should be reliability and:

   a. Ease of installation and maintenance.
   b. Freedom from clogging.
   c. Self priming.
   d. Low cost.
   e. Double suction.

4. The packing around the shaft of a centrifugal pump:

   a. Is such as to need no adjustment or change for the life of the pump.
   b. Is properly adjusted when moderately tightened and still allowing an occasional dripping of water.
   c. Is properly adjusted when tightened as much as possible that no liquid ever escapes.
   d. Should be tightened to the limit every day.

5. Oxygen deficiency can be prevented in the atmosphere of a lift station by:

   a. Lowering the temperature in the station.
   b. Providing good ventilation.
   c. Sealing off the vents.
   d. Not overloading the pumps.
   e. Increasing the speed of the motors.

6. An accumulation of sewage in the dry well (pump pit) of a lift station:

   a. Is unavoidable.
   b. Is not important because no one sees it.
   c. Is recommended by most sewage works operators.
   d. Is unnecessary, shows poor maintenance, may cause damage, and should be prevented.

7. In operating a small sewage pumping station which is provided with two identical pumps it is best to adjust the controls so that:

   a. The pumps turn on together.
   b. One pump does all the work and the second one is held in reserve until the first one is worn out.
   c. The pumps alternate in operation and operate together during periods of high flow.
   d. The pumps operate only when the sewage has reached the level at which it would overflow to a nearby ditch or stream.

8. A positive displacement pump should never be started against a closed valve because:

   a. It will pump nothing.
   b. Excessive pressure may damage the line or the pump
   c. The sludge will spill
   d. The valve will swing open
   e. None of these

9. The most commonly used type of pump in a sludge pumping installation is:

   a. Centrifugal pump
   b. Reciprocating pump of the plunger type
   c. Air ejector pump
   d. Multistage centrifugal pump
   e. Screw pump

10. Wet-wells should be designed so the detention time is no longer than:

    a. 2 hours
    b. 30 minutes
    c. 3 minutes
    d. 24 hours

11. The principal problem that may occur when starting a new centrifugal pump without filling the pump with liquid, is that:

    a. It would not pump.
    b. Failing to lubricate the packing and bearings may cause damage
    c. The pump will deliver a low head pressure only.

12. Pneumatic ejectors are able to lift liquids by means of:

    a. Compressed air.
    b. Water jets.
    c. Piston pumps.

13. Most lift stations are automatically controlled and operations consist primarily of inspection.

    a. True
    b. False

14. A non-clog impeller is designed so an object $3\frac{1}{2}$ inches in diameter will pass through it without causing it to plug.

    a. True
    b. False

15. Lift stations can, in most cases, be classified into two general types.

    a. True
    b. False

CHAPTER III

THE COMPOSITION AND CHARACTERISTICS OF WASTEWATER

CHAPTER III

THE COMPOSITION AND CHARACTERISTICS OF WASTEWATER

Definition of Wastewater

Two terms, wastewater and sewage, are used to describe the dirty, contaminated water treated by a sewage lagoon. Wastewater (or sewage) is the used and discarded portion of a community's water containing the wastes from domestic, industrial or commercial use. Two types of wastewater are usually distinguished: (1) domestic sewage, derived principally from homes, offices, institutions and the like, containing water closet, laundry, and kitchen wastes, and (2) industrial sewage, which is limited to only that waste liquid resulting from manufacturing processes employed in industrial plants.

A lagoon may have to treat either domestic or industrial waste, or a combination of the two types.

Physical Characteristics of Wastewater

Industrial Waste

The amount and characteristics of the waste will vary with the type of process. Variations in the physical, chemical or biological characteristics of a lagoon influent (sewage coming into a lagoon) from the average values given in Table I and described below may be a good indication of the presence of industrial waste. Common indicators of industrial waste include color, odor, temperature, pH, toxic organic chemicals, such as phenols, or pesticides, and toxic inorganic chemicals, such as cyanides or heavy metals.

Toxic organic and inorganic chemicals need to be of concern to the lagoon

operator as in sufficient concentration they can interfere with a lagoon's biological treatment process.

Domestic Waste

TABLE I

Typical Composition of Domestic Sewage

(All values except settleable solids are expressed in mg/liter)

Constituent	Weak	Medium	Strong
Total solids	350	700	1200
Dissolved Solids	250	500	850
Suspended Solids	100	200	350
Settleable Solids (ml/liter)	5	10	20
Biochemical Oxygen Demand, 5-day	100	200	300
Nitrogen, (total as N)	20	40	85
Organic	8	15	35
Ammonia (NH_3)	12	25	50
Nitrites (NO_2), Nitrates (NO_3)	0	0	0
Phosphorus (total as P)	6	10	20
Grease	50	100	150

Fresh domestic sewage has the appearance of turbid, grayish dishwater with a distinctive, somewhat disagreeable odor. The pH will be near 7.0. The sewage will contain floating matter which can be distinguished as matches, bits of paper, soap, rags, garbage, oily patches, etc. In addition, the liquid portion will contain numerous dissolved substances, and millions of bacteria and other microorganisms indistinguishable to the unaided eye. Water is by far the largest constituent, usually at least 99.9%.

Stale or septic sewage is darker in color, sometimes black, and with disagreeable odors caused by the breakdown or organic matter. The most characteristic odor of septic sewage is that of hydrogen sulfide (rotten egg odor). Gas bubbles may be seen rising to the surface. The pH will be below 7.0.

The change from fresh to septic sewage is brought about by the bacteria in the sewage. Once the small initial amount of dissolved oxygen in the sewage has been depleted, bacteria that act in the absence of oxygen (anaerobic bacteria) produce the condition called septic by acting on the solid and dissolved components of the sewage.

Factors in the design of the collection system will contribute to septic conditions. For instance, long collection systems with flat grades will cause the sewage to flow more slowly and give the bacteria more chance to act. Low spots and dead ends in lines create pools which give the same effect. Also, unventilated sewers which exclude oxygen enhance the anaerobic bacteria's action.

Septic sewage usually creates problems for both the wastewater collection department and lagoon operations.

Temperature

The temperature of wastewater is commonly higher than that of the local air temperatures, except during the hottest summer months, due to the addition of warm water from households and industrial activities. Depending on geographic location, the mean annual temperature of wastewater will vary from 50 to 70°F being a representative value.

"GOOD GRIEF WHAT'S COMING IN"

The temperature of wastewater is especially important in its effect on the rate of biological activity and on the solubility of oxygen in water. As temperature increases (within reasonable limits) biological activity increases. Hence, the warmer a wastewater, the faster it will go septic, because the bacteria work faster.

The solubility of oxygen in water is dependent on the temperature and also plays a role in biological activity. As the temperature of the water increases, the amount of oxygen it is capable of holding decreases. This is important because the bacteria that cause septicity in sewage work best in the absence of oxygen and thus a high temperature not only increases their activity but also helps cut down on the amount of oxygen in the water and so favors their growth.

Flow

The amount of sewage reaching a lagoon varies considerably during a 24-hour period. The minimum flow occurs during the early morning hours when water consumption is lowest and all that reaches the lagoon is a small quantity of sewage and leakage and infiltration water. Peak flow occurs in late morning, following the morning peak water demand, with a lesser peak in early evening.

The quantity of sewage generated per person per day varies widely from city to city. It may be anywhere from 40 to 280 gallons per person per day. A usual rule of thumb average is 100 gallons per person per day.

It might seem reasonable that sewage flow for a city would equal potable water consumption. However, actual sewage flow may range from 70 to 130

percent of the water consumption. This is because water may be lost to sprinkling and irrigation, or gained due to industry's use of non-potable process water discharged to sewers. Also, collection systems with infiltration problems will be receiving continuous additional water from ground seepage and periodic influxes of water during periods of rainfall.

Total Solids

Perhaps the most important single characteristic of wastewater is its total solids content. It is mainly the presence of various sorts of contaminating solids that distinguishes "dirty" from "clean" water. One of the lagoon's most important jobs is the reduction of the solids content of wastewater.

Analytically, the total solids content of a water is defined as all the matter that remains as residue upon evaporation at 103°C. This would involve measuring out a certain volume of sewage, evaporating it to dryness in a previously weighed dish, and then weighing the residue. This is a simple procedure, but the term "total solids" may be broken down to distinguish several different types of solids, as outlined below.

Solids may be either dissolved or suspended in the sewage. In domestic sewage 60 to 70 percent of the solids present may be dissolved, the remaining being in suspension.

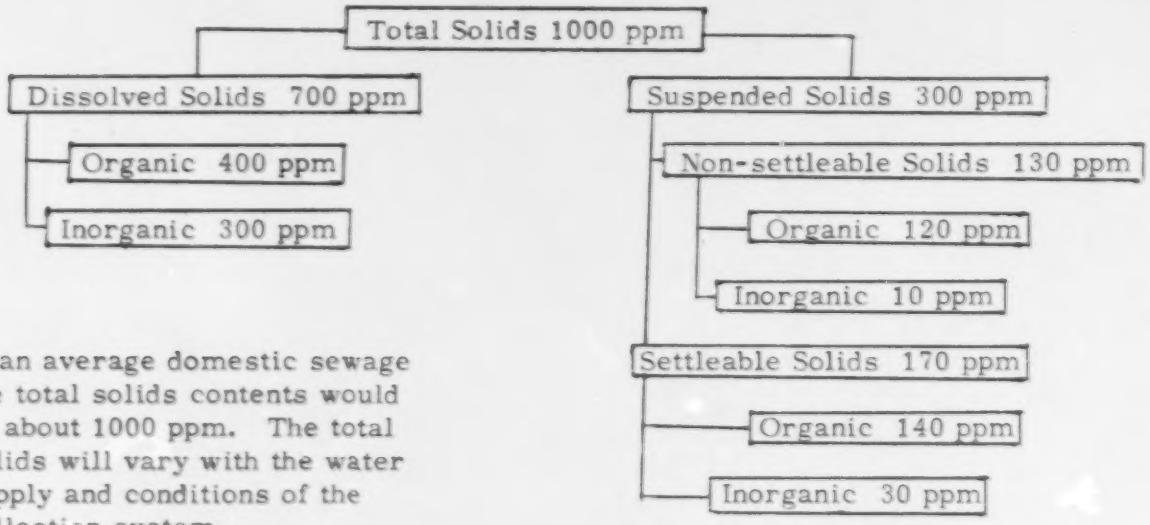
Solids in solution that cannot be filtered out are termed dissolved solids, and may be either organic or inorganic in nature.

Inorganic dissolved solids in sewage are mainly present from the hardness causing minerals and the other minerals in the water supply. An example of inorganic dissolved solids would be the evaporation of a portion of sea water - a thick crust of salt (inorganic solid) would be left behind.

Sugar, when dissolved in water would be an example of a dissolved organic solid.

An easy way to distinguish organic from inorganic solids is that organic (that is, carbon containing) compounds nearly always come from living or once living matter. Hence, a stone is inorganic but a wood chip, coming from a once living tree, is organic.

Solids that can be trapped on the filter during filtration are classified as suspended solids. They will be both organic and inorganic. A further distinction that is made with suspended solids is that the portion of suspended solids that will settle to the bottom of a container in one hour is designated settleable solids. The settleable solids portion consists of heavy organic matter and any sand or silt infiltrating the collection system. The remaining non-settleable suspended solids is mainly very finely divided (colloidal) organic matter. The amount of suspended solids contributed per person per day is about 0.2 pounds.



In an average domestic sewage the total solids contents would be about 1000 ppm. The total solids will vary with the water supply and conditions of the collection system.

Chemical Characteristics of Wastewater

Organic Matter

Organic solids in sewage are mainly composed of proteins from animal tissues, carbohydrates from sugar, starch, and cellulose, and fats, oils and greases from either animal or vegetable matter.

The strength of sewage is determined by measuring the amount of oxygen that will be required by bacteria to oxidize or stabilize the organic matter present. This determination is known as the biochemical oxygen demand (B.O.D.) test. An average B.O.D. for domestic sewage will be between 180 - 250 mg/l. Generally, each person on a collection system will contribute 0.17 pounds of B.O.D. per day. Garbage disposal units in the home will increase the B.O.D. by at least 50%. An excess of B.O.D. could result as a shock load to a sewage treatment plant operation. A shock load is an unexpectedly strong waste, usually hitting a lagoon in a very short period of time. Detailed information on the importance of this test as well as the dissolved oxygen and the other routine tests can be found in Chapter XIV, NPDES Requirements and Laboratory Testing.

If primary treatment is used ahead of a lagoon, the grease that is always present to a greater or lesser degree may cause problems. The grease, fats and oils tend to float to the surface of a tank to form a scum blanket. The presence of scum may be the cause of considerable difficulty in sewage treatment. It may be the cause of fires, explosions, formation of grease balls, and line stoppages. Grease will also form scum on settling tanks, stop-up screens and nozzles, destroy paint, interfere with oxidation and digestion and cause objectionable odors.

Inorganic Matter

pH - The pH value, or hydrogen ion concentration, of wastewater is an indication of its alkalinity or acidity. Most bacteria utilized in wastewater treatment favor slightly alkaline conditions while highly concentrated alkaline or acid solutions will prevent their growth. The pH scale is 0-14, with a pH of 7.0 being neutral. Anything less than 7.0 indicates an acid condition and anything with a pH of over 7.0 indicates an alkaline condition.

Nitrogen, Phosphorus, and Sulfur

The elements nitrogen and phosphorus are essential to the growth of microorganisms and are known as nutrients or biostimulants.

Nitrogen in the waste is mostly in the form of organic nitrogen (proteinaceous matter) and urea from urine. These are broken down by bacteria to form ammonia (NH_3). Nitrate, however, can be utilized by algae in the formation of their proteinaceous body material, and hence can act as an algal stimulator.

Phosphorus is usually present in natural waters in very low concentrations. Chemical and detergent usage will contribute high phosphorus levels to sewage, largely in the form of orthophosphate ($PO_4^{\equiv}$). This can contribute to the growth of undesirably high algae levels in lagoons and receiving water bodies.

Organic sulfur compounds are first broken down by bacteria to form hydrogen sulfide. If free oxygen is present, the hydrogen sulfide will be oxidized to form stable sulfates ($SO_4^{=}$) and as such are usually of little concern to the lagoon operator.

Chlorides (Cl^-)

Chlorides in wastewater come primarily from the potable water of a community. Also, human excreta will add about 6 grams of chloride per person

per day. Additional chloride sources would include runoff from salted streets in winter, flush water from water softeners, and infiltration of ground waters adjacent to salt water.

It is usually economically unfeasible to remove chlorides, and the chloride content of a waste is not affected by conventional treatment. Once the chloride level for a waste has been established, higher or lower than usual concentrations may be significant, high levels possibly indicating a trade waste, and low levels being expected during wet weather when infiltration rates are high.

Chlorides in wastewater will contribute to both the dissolved and total solids content.

Unusual Inorganic Constituents

Trace quantities of cyanide (CN) and any of a number of heavy metals, such as Cr^{+6} (hexavalent chrome), Cd(cadmium), Zn (Zinc), Hg (Mercury), Pb (Lead), Cu (Copper), Mn (Manganese), etc., can interfere with lagoon operation by killing microorganisms. Their control especially from metal working and plating concerns, is important.

Gases in Sewage

Dissolved Oxygen (O_2)

Dissolved oxygen has been mentioned as the agent which prevents sewage from becoming septic. The dissolved oxygen in sewage is derived from oxygen present in the water supply and oxygen picked up from air in the sewer pipes. The presence of dissolved oxygen in sewage is an indication of its freshness, since the process of putrefaction cannot begin as long as there is dissolved oxygen present. Oxygen is quickly consumed by aerobic bacteria while decomposing the organic matter in the sewage.

Hydrogen Sulfide (H_2S)

Hydrogen sulfide is formed by the decomposition or organic matter containing sulfur or from the reduction of mineral sulfites and sulfates by anaerobic bacteria. This reduction will not take place in the presence of dissolved oxygen. The blackening of sewage is usually due to the reaction of H_2S with dissolved iron (Fe^{+2}) in the water to form black FeS (iron sulfide). Although hydrogen sulfide is by far the most important sulfide formed by anaerobic decomposition, other sulfide compounds are possible if the proper starting materials are present and cause much more offensive odors than hydrogen sulfide.

Besides the hydrogen sulfide odor problem, some bacteria are capable of oxidizing H_2S to H_2SO_4 (sulfuric acid) which will rapidly eat away iron and steel pipe and attack concrete. Also, hydrogen sulfide gas is highly toxic and explosive, and all manholes, sewer junctions and wet wells where the gas can accumulate should be thoroughly vented before entering.

Methane (CH_4)

Methane is the principle by-product of anaerobic decomposition of the organic matter in wastewater. Methane is colorless and odorless, but is highly flammable and has a high fuel value. In fresh sewage it is usually present in very small quantities, because even low dissolved oxygen levels kill the bacteria that produce methane. However, methane may be formed in bottom deposits, so any pipe, manhole, junction box or wet well should be thoroughly vented to avoid the danger of explosion.

Carbon Dioxide (CO_2)

Carbon dioxide is an odorless, colorless, gas, formed as a by-product of bacterial decomposition of organic matter. In sewage its danger is that it will also collect in enclosed spaces and will cause rapid suffocation by displacing oxygen in the lungs.

In water carbon dioxide forms carbonic acid (H_2CO_3).

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

It is this formation that lowers the pH of septic sewage. The greater the number of hydrogen ions in the water (H^+) the lower the pH will be.

$$H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

Bacteria and Microorganisms in Sewage

Many types of bacteria will be present in wastewater. Some of these bacteria may be pathogenic, that is, they will produce disease. Some types of bacteria are useful in the treatment processes and are classified according to conditions and environment in which they live and reproduce.

Aerobic Bacteria

Aerobic forms - bacteria and other microorganisms requiring free oxygen (O_2), in order to live and reproduce.

Aerobic bacteria metabolize the organic matter in sewage. This is what purifies the sewage, that is, they break the organic compounds down and use them for food. These bacteria are utilized in secondary treatment (biological treatment), such as lagoons where free oxygen is available.

Anaerobic Bacteria

Anaerobic forms - bacteria and other microorganisms which exist only

in an environment devoid of free oxygen. Their place in lagoon waste treatment is associated with the digestion of the solids that settle to the bottom in shallow lagoons, the upper portions of which contain free oxygen and with deep lagoons where only the uppermost layer of the lagoon contains free oxygen (anaerobic lagoons).

Facultative Bacteria

Facultative forms - bacteria and other microorganisms preferring to exist as aerobic forms, but in the absence of free oxygen, will convert to anaerobic forms. Facultative microorganisms are less readily recognized by the operator because of their versatility. Note: All biological life requires oxygen in some form to sustain life. Where no free oxygen exists, anaerobes take oxygen that is chemically combined by breaking down oxygen containing organic and inorganic compounds.

Coliforms

Coliform bacteria are rod-shaped bacteria that are contained in the intestinal tract of warm-blooded mammals (animal and human) in countless numbers and are excreted by the billions. The bacteria themselves are harmless and even aid in sewage treatment. Their primary usefulness is as an indicator organism. Pathenogenic (disease causing) organisms in wastes are few compared to coliforms and hard to isolate, but the numerous coliforms are easy to test for. The presence of coliform organisms is taken as an indication that pathogenic organisms may be present and their absence is taken as an indication that no pathogens are likely to be present.

Protozoa

In addition to bacteria, sewage may contain large numbers of protozoa. Protozoa are single celled animal organisms including amoebas, flagellates, and ciliates, and are second only to the bacteria in their importance in sewage treatment. The action of protozoa in sewage treatment is not very well understood at present, although they seem to act to preserve a natural balance among the bacteria. Protozoa are bacteria predators, (they eat them) and consume large quantities of bacteria.

Viruses

Viruses excreted by humans can substitute a serious health problem, especially the hepatitus virus, which is waterborn. Much work remains to be done to determine the mechanics of travel and removal from sewage.

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C D E
2. A B C D E
3. A B C D E
4. A B
5. A B
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9. A B C D
10. A B C D E
11. A B C D E
12. A B C D
13. A B C D
14. A B C D E
15. A B C
16. A B C
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21. A B C D
22. A B C D E
23. A B C D E
24. A B C D
25. A B C D
26. A B C D E
27. A B
28. A B C D
29. A B
30. A B C D
31. A B C D E
32. A B C D E
33. A B C D

EXAMINATION QUESTIONS

The Composition and Characteristics of Wastewater

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure which of the answers are correct it is recommended that you look up the answer in Chapter III, Composition and Characteristics of Wastewater. Completely blacken out the letter on the answer sheet that corresponds to the best answer. Fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. Bacteria perform a vital role in sewage treatment. Those that require free oxygen for their life process are called:

   a. Anaerobic bacteria
   b. Protozoic bacteria
   c. Microscopic bacteria
   d. Aerobic bacteria
   e. Amoebic bacteria

2. Nitrates are almost universally determined on treated or partially treated sewage because:

   a. Nitrates measure the carbohydrates in sewage
   b. Nitrates are the final or stable form of oxidized nitrogen
   c. Nitrates combine easily with cellulose
   d. Nitrates measure the presence of oils and fats
   e. Nitrates are readily converted to nitrites

3. Disease-producing bacteria are correctly called:

   a. Saprophytes
   b. Facultative
   c. Parasitic
   d. Pathogenic
   e. Coliform

4. The answers from the total solids and suspended solids tests are always the same.

   a. True
   b. False

5. The B.O.D. test is an indication of the organic content of wastewater.

   a. True
   b. False

6. At the same Barometric pressure the dissolved oxygen in cold water is:

   a. More than the dissolved oxygen in warm water
   b. Less than the dissolved oxygen in warm water
   c. The same as the dissolved oxygen in warm water

7. Bacteria may be classed into three major groups depending on their ability to utilize oxygen:

   a. Oxygen lovers, oxygen haters, and oxygen discriminators
   b. Anaerobic, aerobic, and facultative
   c. Free oxygen, bound oxygen, and no oxygen
   d. None of the above

8. Most of the organic solids in wastewater come from

   a. Dirt
   b. The water supply
   c. Bacteria present
   d. Animal and vegetable materials

9. One of the following may indicate the strength of wastewater

   a. Chlorides
   b. Sulfates
   c. Biochemical oxygen demand
   d. Calcium

10. The cycle of life, death, and decay of organic nitrogenous matter is known as:

    a. The sulphur cycle
    b. The nitrogen cycle
    c. The carbon cycle
    d. The hydrological cycle
    e. The life cycle

11. The physical appearance of septic sewage is described as:

    a. Dark brown or black in color, usually with disagreeable odor
    b. Usually gray in color, having somewhat the appearance and odor of soapy dishwater
    c. Clear color with a nonoffensive odor
    d. Light green with a mossy odor
    e. Light blue with a greasy look

12. Biochemical oxygen demand is:

a. The quantity of oxygen forced through an aeration tank
b. The total demand for oxygen by anaerobic bacteria
c. The quantity of oxygen required to stabilize the organic matter under aerobic conditions
d. The quantity of oxygen in solution from which the bacteria and chemicals can take what they need

13. About how many gallons of domestic wastewater may be expected per person per day?

a. 1,000 gallons
b. 100 gallons
c. 325 gallons
d. 500 gallons

14. A shock load on a wastewater facility is:

a. A heavy flow
b. A big load in a truck
c. An unexpected strong waste
d. An unexpected bump
e. None of these

15. Ground garbage (household disposal units) will increase the household B.O.D. load by at least:

a. 20%
b. 30%
c. 50%

16. One type of bacteria can function either with or without D.O. and is very important in the treatment of sewage. It is called:

a. Aerobic
b. Anaerobic
c. Facultative

17. Wastes derived from plant and animal life are termed:

a. Organic
b. Inorganic
c. Mesophylic

18. The pH scale extends from 1 to 14, with 7 being a neutral solution.

a. True
b. False

19. The B.O.D. of an average domestic sewage is between:

a. 180 - 250 mg/l
b. 1000 - 2000 mg/l
c. 10 - 20 ppm
d. 500 - 1000 ppm

20. Which constituent of sewage is the largest?

a. $B.O.D._5$
b. Total solids
c. Chlorides
d. Water
e. Nitrogen

21. Methane production in sewage

a. Is useful as a form of fuel
b. Is prevented by the presence of dissolved oxygen
c. Is mainly produced by aerobic and facultative microorganisms
d. Is non-flammable but will cause suffocation in enclosed spaces

22. Sewage will become septic because of:

a. The organic matter in the sewage
b. The dissolved oxygen content of the sewage
c. Anaerobic bacteria acting on the sewage
d. The sulfur compounds in the sewage
e. All of the above

23. Coliform bacteria

a. Are necessary for sewage treatment
b. Are disease causing
c. Indicate the possible presence of pathogenic microorganisms
d. Indicate the presence of protozoa
e. In large numbers indicate a waste with a high $B.O.D._5$

24. The temperature of wastewater is usually

a. Higher than that of the local air temperatures
b. Lower than that of the local air temperatures
c. Higher in the hot summer months, lower the rest of the time
d. Lower in the hot summer months, higher the rest of the time

25. Sewage flow is usually

a. Lowest in early morning, highest at evening
b. Highest in late morning, lowest in early morning
c. Highest in early morning, lowest at late morning
d. Lowest in evening and early morning, highest in the late morning and early afternoon

26. Carbon dioxide in sewage

a. Will lower the pH of the sewage
b. Will displace oxygen in the lungs
c. Will eventually cause lung cancer
d. Is essential for bacterial growth
e. None of the above

27. A dissolved solid may be trapped on a filter.

a. True
b. False

28. Phosphorus in sewage:

a. Comes mainly from potable water
b. Is present in very low concentrations
c. Is due in large part to detergents
d. Is oxidized by bacteria to a harmless form

29. Sewage flow for a city usually equals potable water consumption.

a. True
b. False

30. The total solids content of a water is usually about:

a. 300 ppm
b. 400 ppm
c. 700 ppm
d. 1000 ppm

31. Chlorides in sewage:

a. Come mainly from fecal matter
b. Cannot be removed by ordinary treatment
c. Are an indication of trade waste
d. Increase the suspended solids in sewage
e. All of the above

32. Dissolved oxygen is essential for:

a. Lagoon treatment of sewage
b. Facultative bacteria
c. Preventing heavy metal contamination
d. Adequate methane production
e. None of the above

33. Most microorganisms favor an environment that is:

a. Slightly acid
b. Neutral as to acid and base
c. Slightly alkaline
d. Very alkaline

CHAPTER IV

SCREENING DEVICES

CHAPTER IV

SCREENING DEVICES FOR LAGOONS

To assure efficient and proper operation, a lagoon should have preliminary treatment of some kind, especially if it is the only treatment process for a community, industry, etc.

Many large objects such as rags, sticks, and other large solids find their way into the collection system and need to be removed from the sewage flow before entering a lagoon. There are many devices employed today to accomplish this purpose, but the most common devices for lagoons are the bar screen (either mechanically or manually cleaned) and the comminutor.

BAR SCREENS

Purpose

Bar screens are the most commonly used device for the removal of large floating objects, rags, etc., from the sewage flow that would interfere with normal lagoon operations.

Theory

Bar screens are composed of a set of bars placed on a slope of 30° to 60° in the flow channel where raw sewage enters the lagoon. Influents to lagoons are not always from one end. Lagoon inlets may enter from 1/3 the distance of the ponds length to some place near the center. Consideration must be given to the location of a screening device when designing and building a lagoon system.

The openings between bars usually varies from 1" to 2", but may be as narrow as 5/8" on mechanically cleaned screens. Spacing of the bars is important, as too narrow a spacing will remove too many of the solids and

cause sewage to back up in the outfall lines. This, in turn, will result in settling of organic materials, depletion of dissolved oxygen, and septic conditions which, when released, may seriously overload a lagoon. On the other hand, spacings too wide will allow large solids to pass through to the lagoon. This situation results in sludge on the bottom of the lagoon to build up too rapidly, resulting in possible septic conditions.

Bar screens are cleaned in one of two ways: manually or mechanically. In the case of manually cleaned screens, the operator must use a rake of some sort to manually pull the screenings up to the top of the screen where they are deposited on a drainage floor. Several precautions should be noted here:

1. The screen slope should be 30° to 45° for ease of cleaning.
2. The screen should be cleaned regularly so as not to allow the solids to build up on the screen.
3. Screenings should be removed promptly, stored in a fly-tight can, and disposed of properly.

In some systems, mechanically cleaned screens may be in use. The principle of operation is basically the same, the exception being that the screenings are removed by some type of mechanical rake. There are many types of mechanical rakes available, but all of them employ some mechanical means to remove screenings with a high degree of efficiency. Most mechanically cleaned screens use a float-controlled switch to operate the rake mechanism automatically when the screenings build up to a predetermined head. Disposal of these screenings may be run through a grinder and returned to the sewage flow. However, this practice will impose an additional organic load on the lagoon which may be enough to overload it and thereby decrease its efficiency.

Frequently Encountered Difficulties

1. Improper or infrequent cleaning or disposal of screenings is likely to lead to fly breeding problems, odor problems, and rodent problems.
2. Neglect in cleaning of screens may cause a build-up of solids which in turn will cause sewage to back up in the outfall line. This condition will cause solids to settle out and result in septic conditions. When the screen is finally cleaned, a slug flow of septic sewage will enter the lagoon causing odor problems, possible septic conditions in the lagoon, and a lowering of effluent quality.
3. In the case of mechanically cleaned screens, attention should be given to proper lubrication and maintenance.
4. In cold weather, a mechanical rake should be operated continuously to prevent it from freezing to the screen.

Determination of Loadings

Bar screen loadings are usually expressed in terms of cubic feet of screenings removed per million gallons of sewage. The amount of solids that will be removed may vary from 0.5 cubic foot to 6.0 cubic feet per million gallons of sewage, depending on the size of screen openings.

The screenings will contain about 80% moisture and will be high in putrescible material. Screens should have sufficient space between the bars to prevent velocities greater than three feet per second from passing through them. At velocities of more than three feet per second, some material that should be removed will be forced through the screen. Thus, the important factors contributing to removal are the velocity of sewage through the screen, the clear

opening space between bars, and the potential head loss available before a clogged screen causes back up in the outfall line.

Methods of Operation

1. Clean, oil, and grease all moving parts of mechanical cleaning devices at routine intervals as recommended by the manufacturer.
2. Remove and dispose of screenings promptly by:
   a. Burial under 18" of earth
   b. Incineration (must have a scrubber on incinerator)
   c. Storage in a fly-tight metal can for periods not to exceed three days prior to burial or incineration, depending on temperature ranges.
3. Thoroughly clean the screen chamber and rack at least once per day to remove all accumulation of sludge and grease, etc.
4. Turn the electrical power off before working on mechanically cleaned screen.

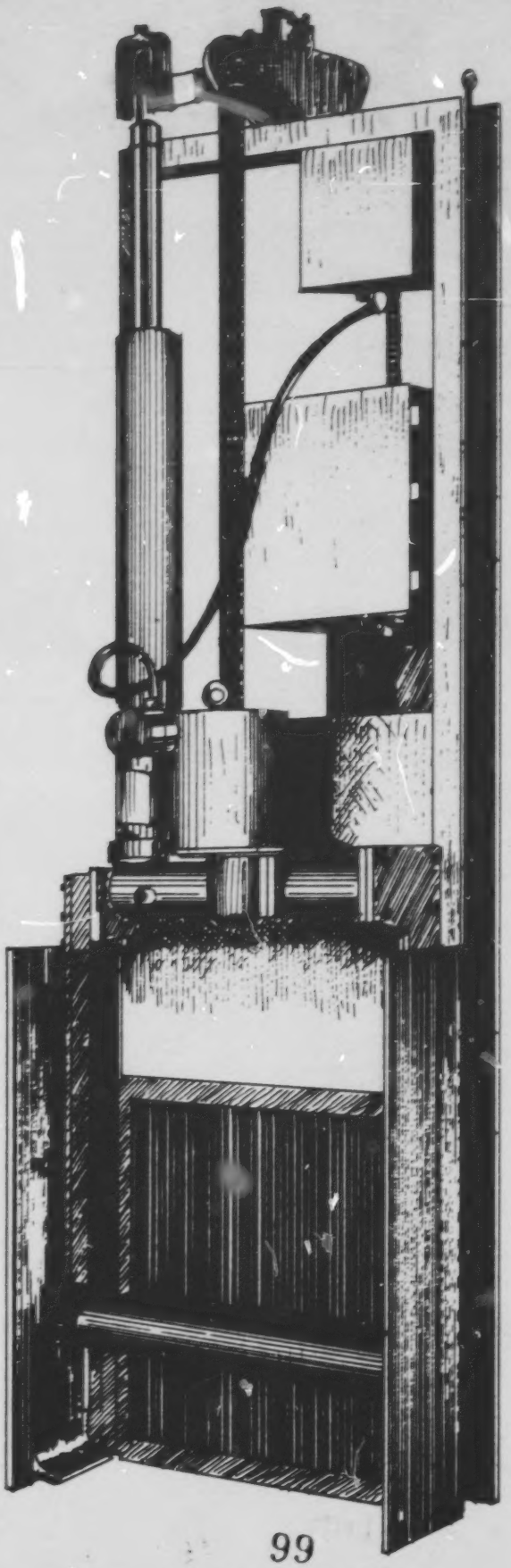
Records

1. Cubic feet of screenings removed daily.
2. Maintenance to the bar screen.
3. Lubrication and servicing of the mechanically cleaned screen.

COMMINUTOR

Purpose

Comminutors are installed in the flow channel in such a manner that all sewage passes through the device. The large particles of floating and suspended solids are cut or shredded into material sizes which will readily settle



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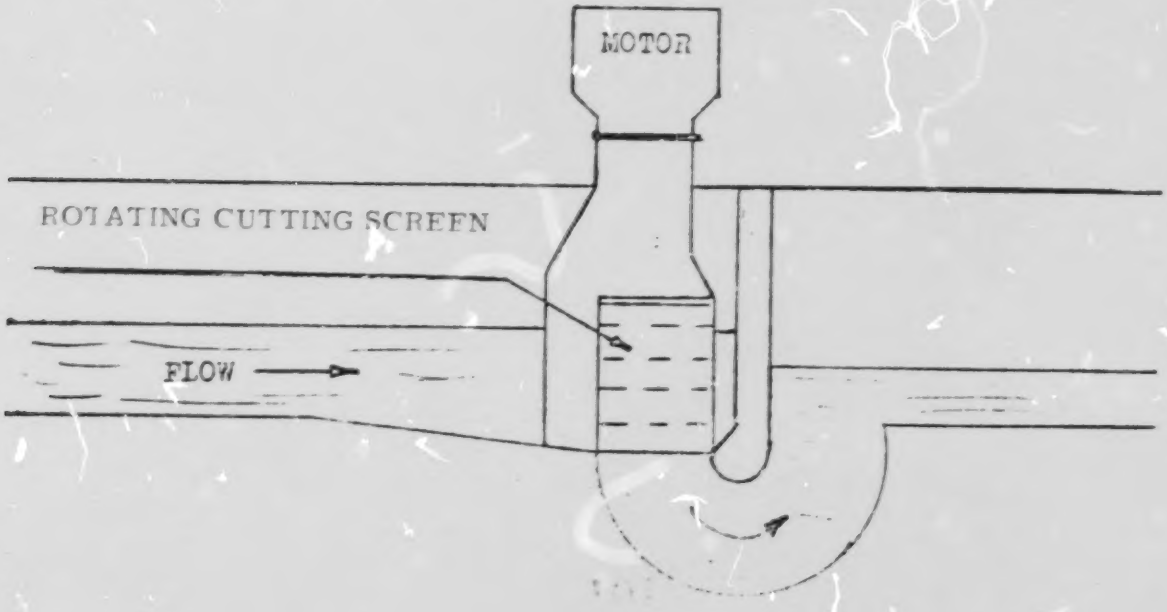
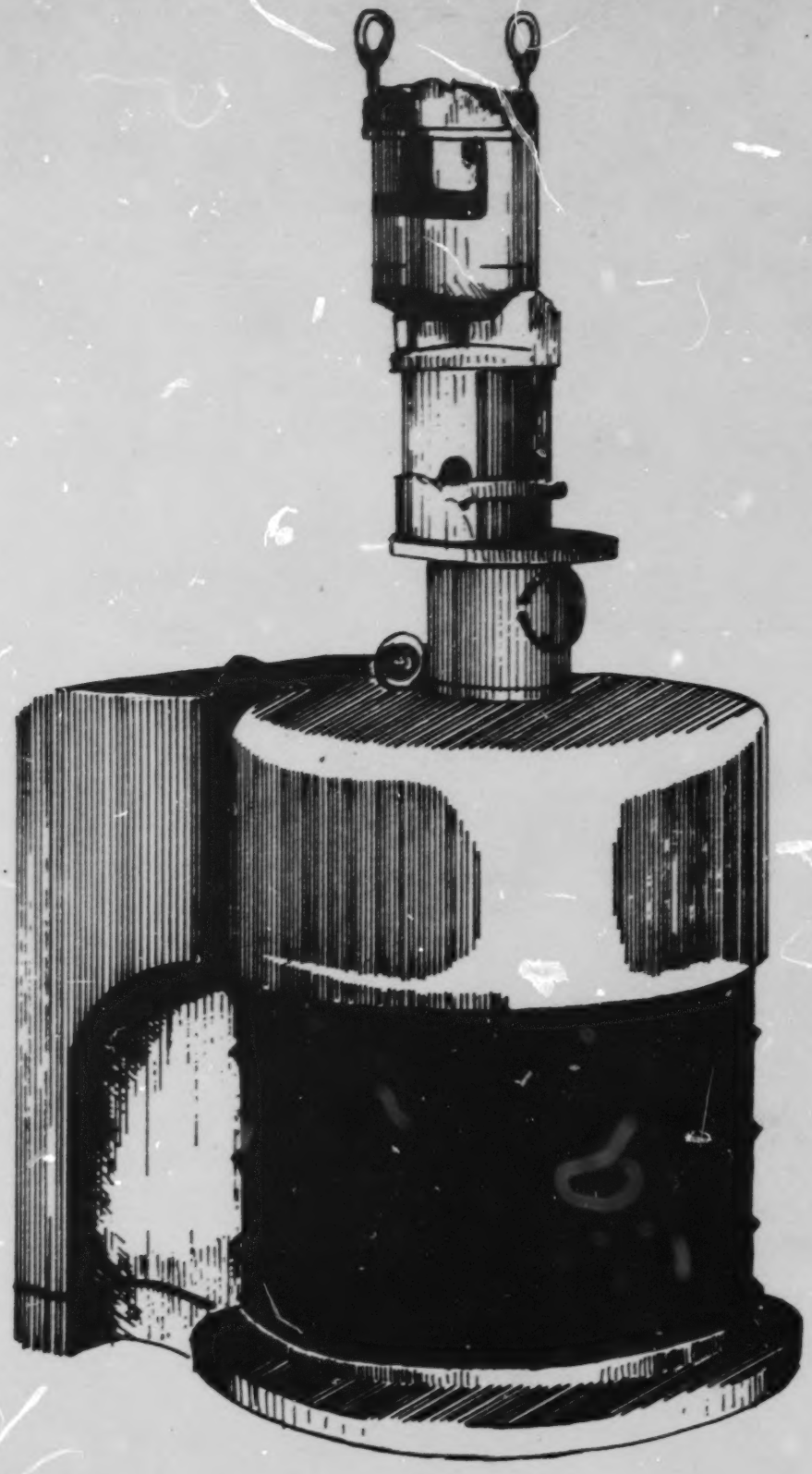
BARMINUTOR

and which will not harm mechanical equipment, clog piping, or cause problems in the lagoon. These smaller particles also expose more surface area to activity of biological organisms, resulting in more rapid stabilization of solids--which is highly desirable in a lagoon operation.

Theory

Comminutors, sometimes called shredders, consist of a curved slotted screen with a motor-driven cutting head, which by oscillation or rotation, cuts or shreds solids to sizes which can readily settle, be decomposed by the microorganisms, and will not cause clogging problems. By reducing particle size and returning the solids to the sewage, an improved settling characteristic is realized as well as elimination of screenings that need to be disposed of by burial or incineration. Some models also provide grinding of screenings removed from mechanically cleaned bar screens. Because mechanical or operational failure can occur, a by-pass channel with a manually cleaned bar screen is usually constructed parallel to the comminutor channel.





COMMINUTER

IV-7

Difficulties Frequently Encountered

1. Failure of cutting heads due to excessive wear. Grit chambers should precede shredding devices if excessive grit is present.
2. Failure due to improper maintenance schedules. Cleaning, oiling, and greasing is essential as in the case of all mechanical equipment.

Determination of Loading

Shredding devices are similar to pumps with regards to efficiency and head loss curves. Charts can be obtained from the manufacturer of the equipment which will describe optimum operating ranges. In general, the screen area should not be completely submerged except for short periods during high flows. The comminutor is usually operated continuously.

Methods of Operation

1. Remove daily all solids which cannot be reduced by the cutting head. Adjust, sharpen, or replace cutters as needed.
2. Clean, oil and grease moving parts at routine intervals as recommended by the manufacturer.
3. Washing the comminutor down with a high pressure water hose daily is a good practice.

Records

1. Maintenance of comminutor.
2. Log of servicing and repair.

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C D
2. A B C D
3. A B C D
4. A B C
5. A B C D
6. A B C D
7. A B C D
8. A B C D E
9. A B C D E
10. A B C D E
11. A B C D E
12. A B C D
13. A B C D E
14. A B C D
15. A B C D E

EXAMINATION QUESTIONS

Screening Devices

Read each question carefully, circle the letter for the corresponding correct answer. If you are not sure of the correct answer it is recommended that you look up the answer in Chapter IV (SCREENING DEVICES). Completely blacken out the letter on the answer sheet to correspond to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. If the cleaning of a bar screen is neglected, some trash will be forced through it by the flowing sewage. This will:

   a. Increase the B.O.D. loading on the secondary portion of the process to an objectionable extent.
   b. Interfere with the operation of pumps, valves and similar mechanics.
   c. Cause an excessive load of volatile solids to be pumped to the digester.
   d. Help the operator, as then he doesn't have to be concerned with disposing of as large a volume of screenings.

2. The following items may be found in a treatment plant influent:

   a. Cans
   b. Sticks
   c. Toys
   d. All of these

3. A bar screen or a screening grinder is usually installed at a sewage treatment works. The main purpose of this unit is to:

   a. Control the velocity of the flowing sewage.
   b. Remove the non-volatile matter from the sewage.
   c. Remove or break up sticks, rags, and other debris, so as to prevent clogging of valves and pumps.
   d. Reduce the B.O.D. of the sewage.

4. In larger plants the screenings are usually disposed of by:

   a. The use of grinders and returning them to the sewage.
   b. Burning
   c. Burying

5. In small plants, sewage screenings are usually disposed of by:

   a. Discharging them into the effluent
   b. Burying them
   c. Leaving them on the bar screen
   d. Stockpiling them

6. The main purpose of screening is to:

   a. Thin the wastewater
   b. Remove large objects and debris
   c. Remove sand and grit
   d. Separate and classify dissolved solids

7. What should be done first if a problem develops in a mechanically cleaned screen?

   a. Reach in with your hand and fix the equipment
   b. Attempt to fix the screen with the proper tools
   c. Turn off the electrical power to the screen
   d. Find someone to help in case you get into trouble

8. A comminutor is a device for:

   a. Transportation
   b. Shredding of sewage solids
   c. Grease collection
   d. Measuring B.O.D.
   e. Transmitting messages

9. In a lagoon system, grinding and returning to the waste stream of solids may:

   a. Over-work the lagoon
   b. Cause rapid sludge build-up
   c. Decrease lagoon efficiency
   d. All of the above
   e. None of the above

10. Accumulation of solids on a bar screen will cause the following:

   a. Sewage back-up into the outfall
   b. Septic conditions in sewer lines
   c. Depletion of D.O.
   d. None of the above
   e. All of the above

11. A comminutor should be used with what kind(s) of back-up system(s)?

a. Grit chambers
b. Bar screen
c. Nothing
d. Both a & b
e. Both b & c

12. Velocity through a bar screen should be no greater than:

a. 8 fps
b. 5 fps
c. 3 fps
d. 1 fps

13. During periods of cold weather, a mechanical bar screen should be run continuously.

a. Because there are more solids in the sewage
b. To prevent freezing
c. To evenly wear all moving parts
d. All of the above
e. Both a & b

14. If there is excessive grit in the sewage, a comminutor should have a grit chamber ahead of it. Why?

a. To keep flow at required velocity
b. To provide for flow measurement
c. To keep the shredder blade from wearing out too fast
d. None of the above

15. Screenings should be stored no longer than_____prior to disposal.

a. 24 hours
b. 48 hours
c. 72 hours
d. 1 week
e. 10 days

CHAPTER V

FLOW MEASURING

CHAPTER V

FLOW MEASUREMENT FOR LAGOONS

Purpose

All lagoons should be equipped with flow measuring devices. The influent (incoming flow) and the effluent (discharge flow) should be measured as accurately as feasible. The purpose for measuring the incoming flow is primarily for determining both the hydraulic loading and the organic loading flowing into the lagoon treatment facility.

The lagoon was designed to give efficient treatment to a certain number of gallons or acre feet of wastewater per day (hydraulic design capacity). The same applies to organic loading, whether designated in pounds B.O.D. per acre per day or in population equivalent (P.E.) per acre of lagoon surface area at a specified operating depth. Without reasonably accurate flow measurement of the influent and without reliable tests of B.O.D., suspended solids, etc., there is no practical method for determining when a facility has reached or exceeded design capacity. Obviously a B.O.D. or suspended solids test cannot be translated into total pounds per day until the daily flow is determined. Flow measurements provide the basic operating data for determining treatment facility efficiency and for the cost of treating a given amount of wastewater.

Flow measurements also provide basic data for routine operational procedures, especially where the design of the facility permits some flexibility of flow control as in parallel operation of lagoons, retention time and operating depth.

Flow measurements over an extended period of time provide very important data for long range planning of expansion, modification, and/or replacement.

Flow measurments should be taken into consideration when calculating chemical dosages and when planning other operational procedures such as sludge pumping where the lagoon is preceded by a primary clarifier or followed by a final clarifier. N.P.D.E.S. permits almost invariably require flow measurement of the effluent discharge. Without accurate flow measurement there is no practical method of translating effluent analysis (tests) into useful information indicating the effect of the effluent on the receiving waters.

Flow measurements, just as laboratory tests, should be as nearly accurate as feasible and should be reordered for immediate use as well as for future use.

Without valid flow information, operating reports are of little or no value to either the regulatory agencies or the lagoon operating staff.

Methods and Theory

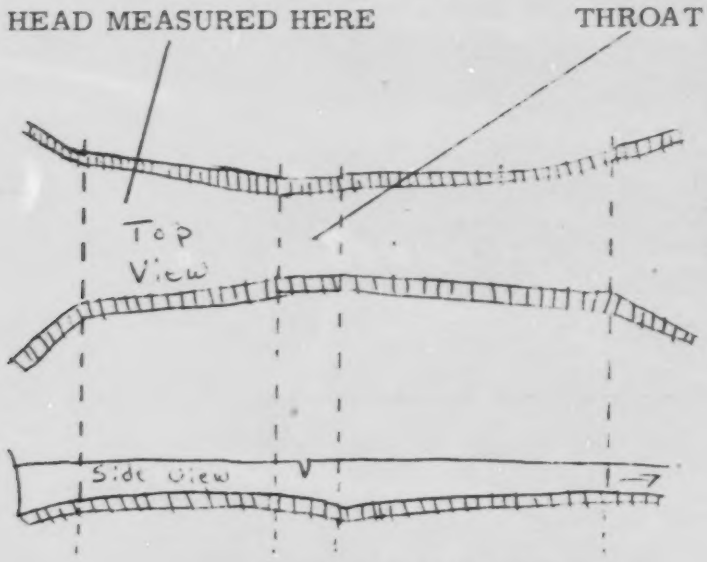
Several methods of flow measurement are available. The two most commonly used are the Parshall Flume and Weir. Another simple method of measuring flow is by noting the change in water level in a tank being pumped, in a measured time.

$$\frac{\text{(in feet) AREA OF TANK} \times \text{(in feet) CHANGE IN LEVEL} \times 7.5}{\text{MINUTES PUMPED}} = \text{GALLONS PER MINUTE}$$

Parshall Flume

The parshall measuring flume is widely used to measure sewage flows because of its simplicity and its freedom from difficulties with sand or suspended solids.

A float or gauge well is sometimes connected to the flume by a pipe. The floats and gauges are obtainable from instrument manufacturers, either for indication of flow or recording and totalizing. The connecting pipe should be valved and arranged for easy cleaning and should be level or sloped toward the flume. It is also recommended that a flow of clear water be directed into the well so that there will be flow from the well to the flume. If the clear water is from the potable supply pipe should terminate at least 2" above the top wall of the well.



PARSHALL FLUME

The head over the crest of a Parshall Flume can be measured by placing a gauge stick in the sewage at the float in the flow channel or at the pipe leading to the float well and then taking reading off the free-flow discharge chart.

FREE FLOW DISCHARGE--PARSHALL FLUME--GALLONS PER MINUTES

HEAD IN INCHES	SIZE OF FLUME - W				
	3"	6"	9"	12"	18"
1-3/16	10.3	22.4	40.0		
1-13/16	22.4	44.9	76.3		
2-3/8	36.7	71.6	116.9	157.1	229.0
3	51.6	103.3	166.1	219.9	318.7
3-5/8	69.0	139.2	219.9	287.3	422.0
4-3/16	68.0	175.1	278.0	359.0	534.0
4-13-16	104.0	215.5	341.1	444.3	659.0
5-3/8	130	260	404	534	790
6	152	310	476	624	925
6-5/8	180	359	552	727	1073
7-3/16	202	413	628	826	1225
7-13/16	233	467	714	934	1387
8-3/8	257	525	799	1046	1553
9	294	588	889	1158	1728
9-5/8	315	651	978	1280	1912
10-3/16	357	714	1073	1400	2096
10-13/16	378	781	1171	1530	2289
11-3/8	420	853	1274	1661	2491
12	448	925	1377	1795	2692
13-3/16		1077	1594	2074	3119
14-3/8		1234	1822	2370	3564
15-5/8		1400	2060	2675	4035

If readings are to be recorded in gallons per day, multiply the answer in gpm by 1440.

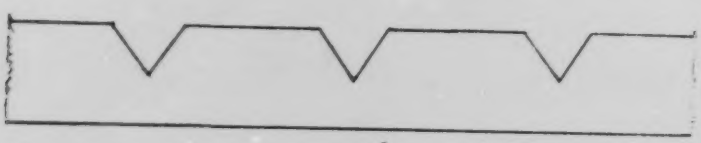
V-Notch Weir

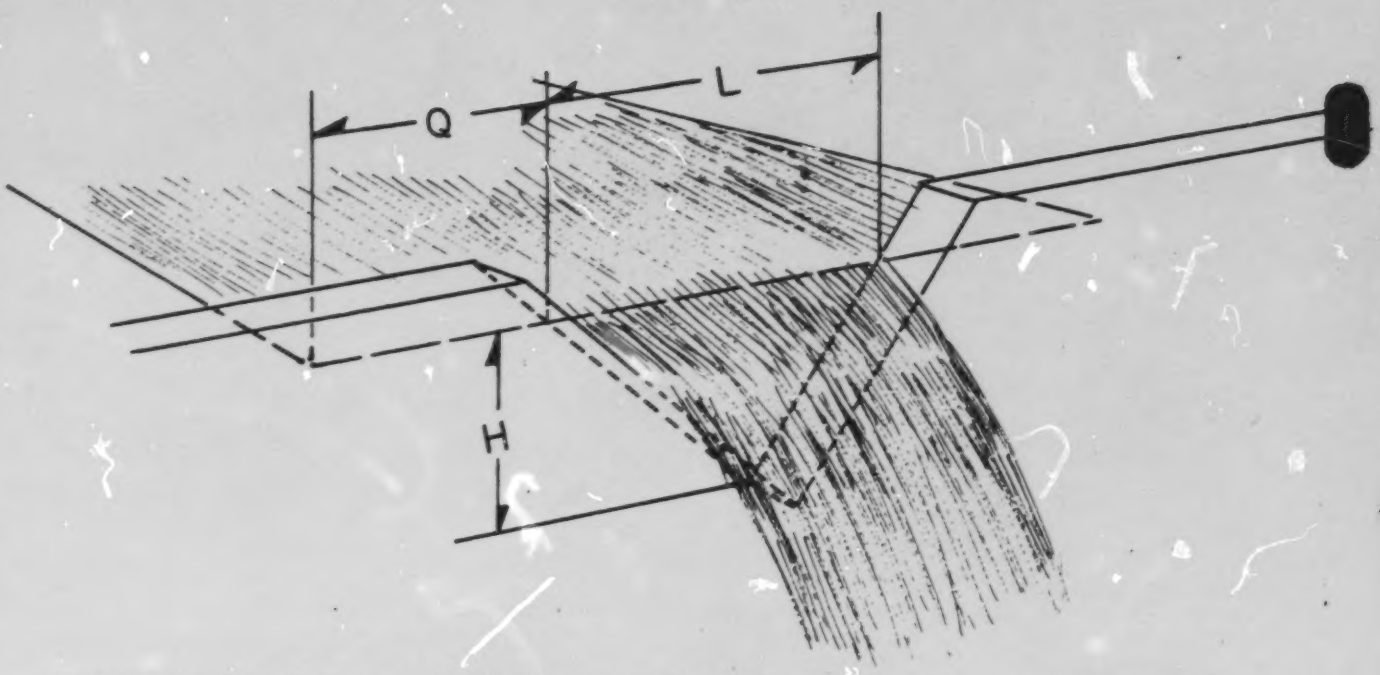
The weir is the least accurate of the measuring devices but it has the advantage of simplicity. To determine flow it is only necessary to measure the head of water above the crest of the weir. The sharp crest weir may be a metal plate up to $\frac{1}{4}$" in thickness.

Clarifiers are almost without exception, equipped with an overflow weir which may be circular, square, rectangular, or straight, depending on the design of the clarifier. These overflow weirs may be smooth crested, "saw-toothed" or notched but are not to be considered as flow measurement devices. Their main function is to provide more nearly even distribution of the discharge from the clarifier thereby reducing the possibility of excessive "short circuiting" through or across the unit in which weir is installed.

V-notch flow measurement weirs are usually constructed with either a 60° or 90° notch. The 60° V-notch weir is generally installed for measuring flows in the lower ranges.

In addition to being inaccurate to some degree, the V-notch weir is usually installed in a concrete flow structure which allows grit and heavy organic solids to settle out. This creates a condition that requires frequent cleaning and flushing of the flow channel. The V-notch of the weir catches and holds trash and debris. This requires frequent cleaning. The edges of the notch of the weir should be leveled on the downstream side to form a "sharp" crest or edge of about 45° angle.





DISCHARGE FROM TRIANGULAR NOTCH WEIRS WITH END CONTRACTIONS

BASED ON FORMULA:

$$Q = (C)\ (4/15)\ (L)\ (H)\sqrt{2gH}$$

in which Q = flow of water in cu. ft. per sec.

L = width of notch in ft. at H distance above apex.

H = head of water above apex of notch in ft.

C = constant varying with conditions, .57 commonly

a = should be not less than 3/4 L.

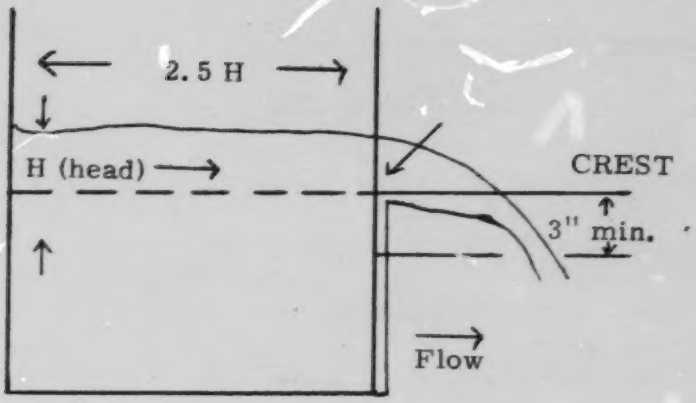
For 90° notch the formula becomes

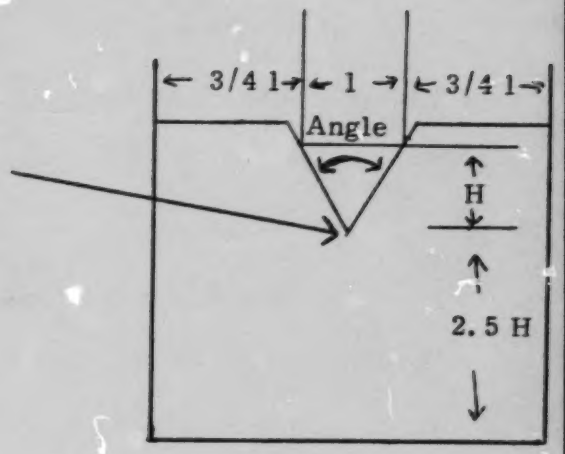
$$Q = 2.536\ H^{5/2}$$

For 60° notch the formula becomes

$$Q = 1.408\ H^{5/2}$$

V-NOTCH WEIR





1. Confirm angle of "V".
2. Head is vertical distance from "V" crest to liquid level taken at a distance 2.5 x head up-stream from weir plate.
3. Liquid depth below crest should be at least 2.5 x head.
4. Liquid down-stream of weir plate should be no higher than 3" below crest of weir.
5. Flow over weir is related to head (H) reading.

   Example: 90^{o} V-Notch Weir

   $1\frac{1}{2}$ " head

   From table flow would be 6.05 gpm

Other Flow Measurement Devices

A considerable number of flow metering devices are available and are giving satisfactory service at lagoon installations. The adaptability of a certain type of flow meter for a given location depends on several factors, therefore, a well qualified individual should be consulted before a final decision is reached.

Flow meters may be controlled by the flow of liquid through a pipe or by the level of liquid in a channel. Some meters only give the flow reading on a dial, others may be recording and totaling. Some type of a float is most commonly used as a "sensing" device. Recording meters are usually powered by electricity. Spring wound types have been used successfully at isolated locations. Portable battery powered meters are used frequently. Regardless of what type of flow measurement equipment is being used, this equipment performs a very important function and should be properly maintained. Mechanical meters should be checked at regular intervals to determine if recalibration is necessary.

DISCHARGE FROM TRIANGULAR V-NOTCH WEIRS

Head (H) in Inches	Flow in Gallons Per Min.		Head (H) in Inches	Flow in Gallons Per Min.	
	90° Notch	60° Notch		90° Notch	60° Notch
1	2.19	1.27	6-3/4	260	150
1-1/4	3.83	2.21	7	284	164
1-1/2	6.05	3.49	7-1/4	310	179
1-3/4	8.89	5.13	7-1/2	338	195
2	12.4	7.16	7-3/4	367	212
2-1/4	16.7	9.62	8	397	229
2-1/2	21.7	12.5	8-1/4	429	248
2-3/4	27.5	15.9	8-1/2	462	267
3	34.2	19.7	8-3/4	498	287
3-1/4	41.8	24.1	9	533	308
3-1/2	50.3	29.0	9-1/4	571	330
3-3/4	59.7	34.5	9-1/2	610	352
4	70.2	40.5	9-3/4	651	376
4-1/4	81.7	47.2	10	694	401
4-1/2	94.2	54.4	10-1/2	784	452
4-3/4	108	62.3	11	880	508
5	123	70.8	11-1/2	984	568
5-1/4	139	80.0	12	1,094	632
5-1/2	156	89.9	12-1/2	1,212	700
5-3/4	174	100	13	1,337	772
6	193	112	13-1/2	1,469	848
6-1/4	214	124	14	1,609	929
6-1/2	236	136	14-1/2	1,756	1,014

Flow From Open End Pipes

The flow from an open end pipe is another means of measuring flow from a lagoon. This method of measuring flow is usually done without building or constructing any device.

DISCHARGE FROM TRIANGULAR NOTCH WEIRS

WITH END CONTRACTIONS

Head in Inches	Flow in Gallons Per Minute 90° Notch	60° Notch
1	2.19	1.27
1 1/4	3.83	2.21
1 1/2	6.05	3.49
1 3/4	8.89	5.13
2	12.4	7.16
2 1/4	16.7	9.62
2 1/2	21.7	12.5
2 3/4	27.5	15.9
3	34.2	19.7
3 1/4	41.8	24.1
3 1/2	50.3	29.0
3 3/4	59.7	34.5
4	70.2	40.5
4 1/4	81.7	47.2
4 1/2	94.2	54.4
4 3/4	108	62.3
5	123	70.8
5 1/4	139	80.0
5 1/2	156	89.9
5 3/4	174	100
6	193	112
6 1/4	214	124
6 1/2	236	136
6 3/4	260	150
7	284	164
7 1/4	310	179
7 1/2	338	195
7 3/4	367	212
8	397	229
8 1/4	429	248
8 1/2	462	267
8 3/4	498	287
9	533	308
9 1/4	571	330
9 1/2	610	352
9 3/4	651	376
10	694	401
10 1/2	784	452
11	880	508
11 1/2	984	568
12	1094	632

Water discharging from a pipe is pulled by gravity toward the earth's surface; how far from the end of the pipes to where it drops depends on the velocity of water coming out of the pipe.

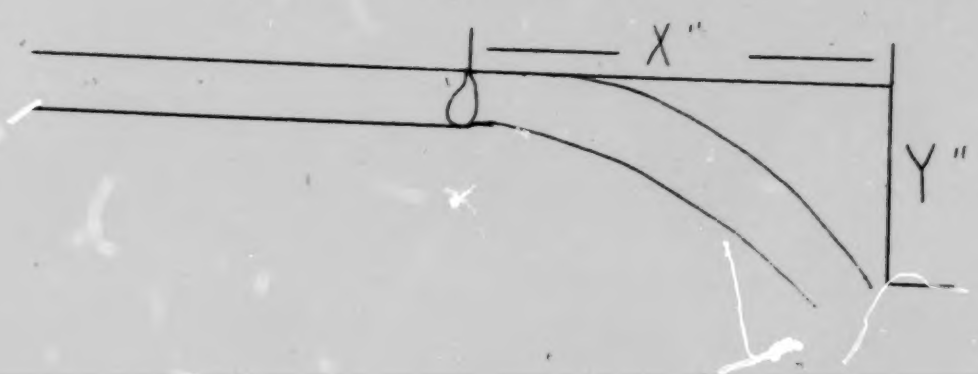
The equation for calculating the flow from a pipe is $Q = \frac{3.61\ AX}{Y}$

Q = Quantity in gpm

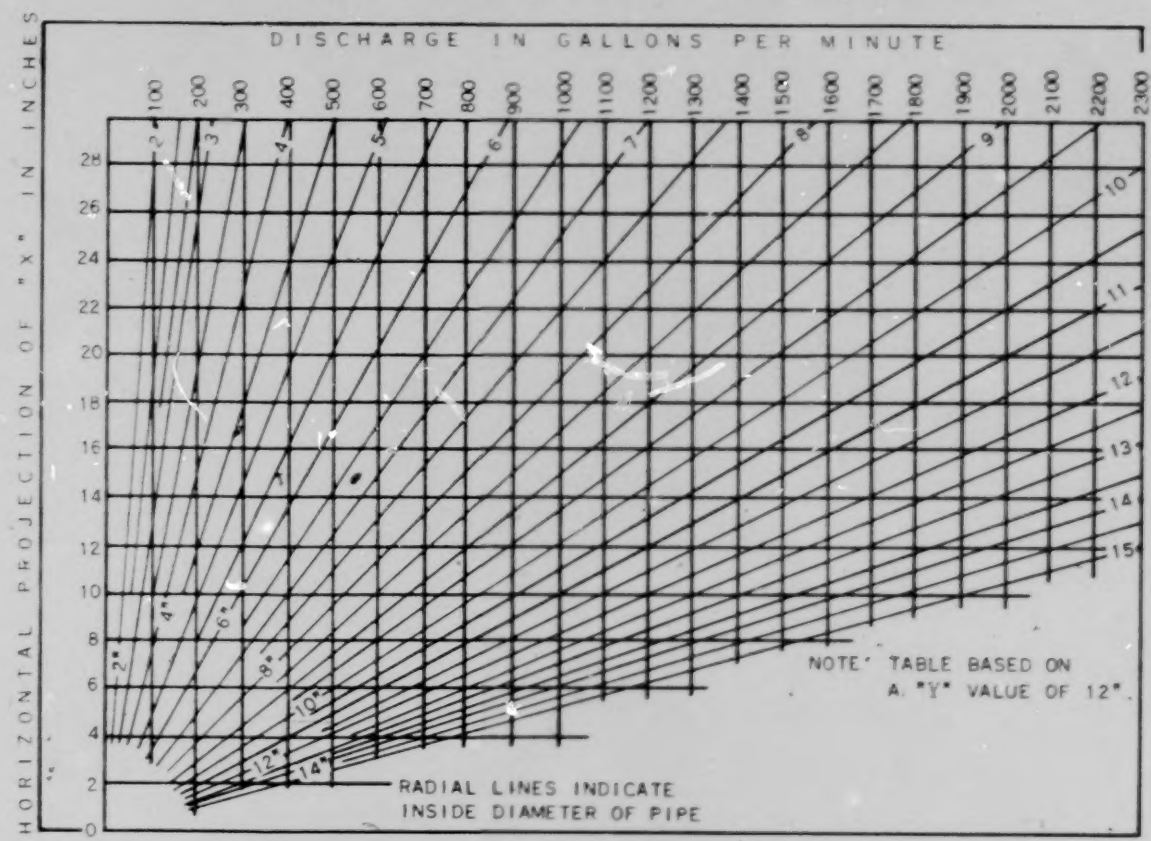
A = Area of water in the pipe in square inches

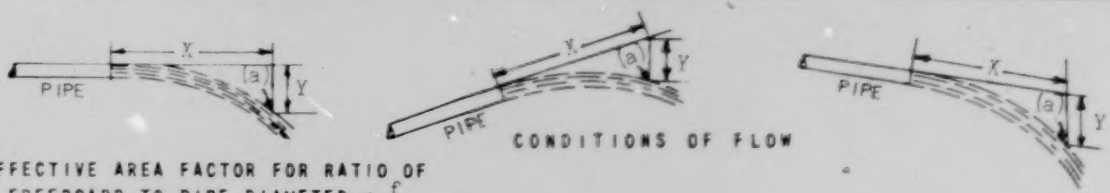
X = distance in inches to the Y measurement from the end of the pipe

Y = the distance in inches the water drops



MEASUREMENT OF FLOW FROM OPEN END PIPES





CONDITIONS OF FLOW

EFFECTIVE AREA FACTOR FOR RATIO OF FREEBOARD TO PIPE DIAMETER = $\frac{f}{D}$

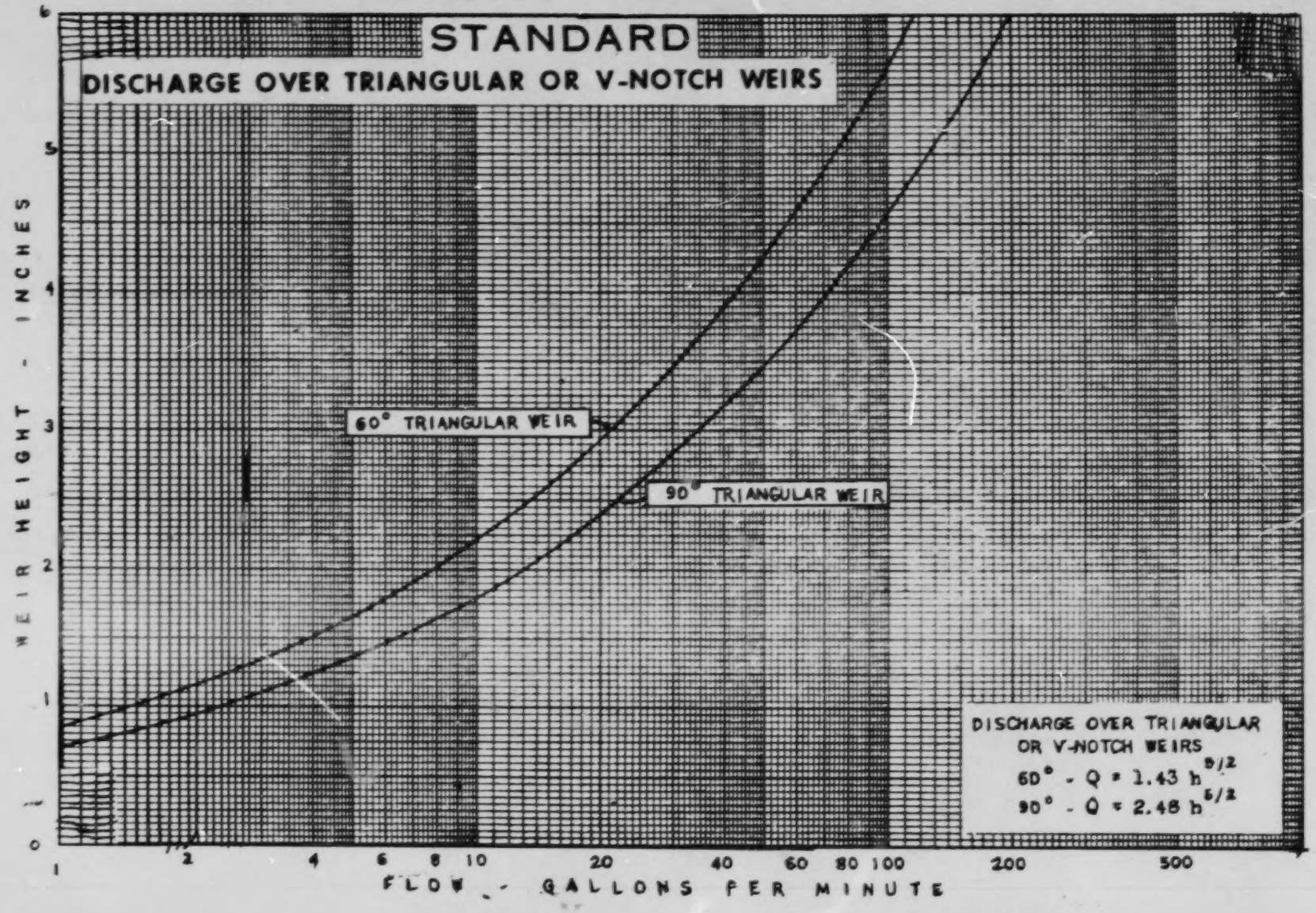
f÷D	FACTOR	f÷D	FACTOR
0.10	0.948	0.31	0.735
0.11	0.939	0.32	0.723
0.12	0.931	0.33	0.712
0.13	0.922	0.34	0.700
0.14	0.914	0.35	0.688
0.15	0.905	0.36	0.676
0.16	0.896	0.37	0.664
0.17	0.886	0.38	0.651
0.18	0.877	0.39	0.639
0.19	0.867	0.40	0.627
0.20	0.858	0.41	0.614
0.21	0.847	0.42	0.602
0.22	0.837	0.43	0.589
0.23	0.826	0.44	0.577
0.24	0.816	0.45	0.564
0.25	0.805	0.46	0.551
0.26	0.793	0.47	0.538
0.27	0.782	0.48	0.526
0.28	0.770	0.49	0.513
0.29	0.759	0.50	0.500
0.30	0.747		

GENERAL FORMULA $Q = \frac{3.61\,AX}{\sqrt{Y}}$

WHERE Q = DISCHARGE IN GPM
A = INTERIOR AREA OF PIPE IN SQ. INCHES
Y = VERTICAL DROP IN INCHES OF TOP OF DISCHARGE STREAM
X = DISTANCE FROM END OF PIPE TO POINT OF FALL MEASUREMENT = POINT (a)

EXAMPLE

1. FOR FULL PIPE DISCHARGE WITH X = 16"; Y = 12"; DISCHARGE = 327 GPM
2. WHEN WATER SURFACE IS 2" BELOW TOP OF PIPE f÷D=0.40; FACTOR=0.627; DISCHARGE=205 GPM.


STANDARD
DISCHARGE OVER TRIANGULAR OR V-NOTCH WEIRS
WEIR HEIGHT - INCHES
0
1
2
3
4
5
6
60° TRIANGULAR WEIR
90° TRIANGULAR WEIR
DISCHARGE OVER TRIANGULAR OR V-NOTCH WEIRS
60° - Q = 1.43 h^5/2
90° - Q = 2.48 h^5/2
1
2
4
6
8
10
20
40
60
80
100
200
500
FLOW - GALLONS PER MINUTE

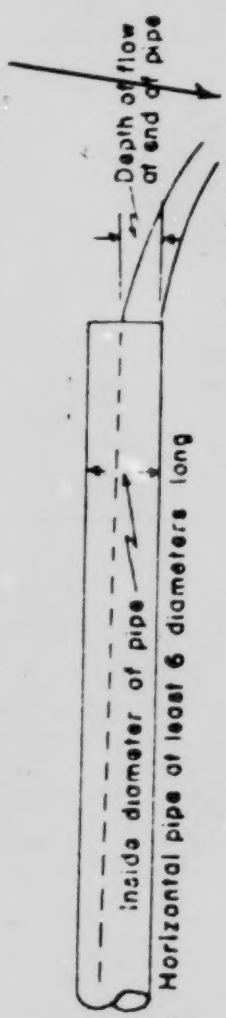
V-13

CALIFORNIA PIPE METHOD FOR HORIZONTAL PIPES FLOWING PARTIALLY FULL.

Adopted and modified from "King, Handbook of Hydraulics"

Lay a straightedge connecting diameter of pipe with depth of flow. The intersection with the quantity scale gives the rate of flow.

NOTE: The depth of water can easily be obtained by subtracting the distance between the water surface and the inside top of pipe from the pipe diameter.



Example

6" Dia. pipe
2" Head (Flow)
Read *
90 gpm

DIAMETER OF PIPE IN INCHES

DIAMETER OF PIPE IN FEET

QUANTITY IN GALLONS PER MINUTE

QUANTITY IN CUBIC FEET PER SECOND

DEPTH OF FLOW IN INCHES

DEPTH OF FLOW IN FEET

TEXAS BOARD OF WATER ENGINEERS
AUSTIN, TEXAS

AUG. 4, 1939

122

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C
2. A B
3. A B C D
4. A B
5. A B C D
6. A B C D
7. A B C D
8. A B C
9. A B C
10. A B C

EXAMINATION QUESTIONS

Flow Measuring

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter 9, Flow Measuring. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign, and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. Flow records provide:

   a. Data to control plant processes
   b. Data on how much wastewater was lost in treatment
   c. Information on the capacity of the collection system

2. Weirs and Parshall Flumes are used to measure the electrical power input to sewage treatment plants.

   a. True
   b. False

3. The most common measuring device used for wastewater flow is:

   a. The venturi meter
   b. The Parshall Flume
   c. A weir
   d. A gallon bucket

4. The purpose of the adjustable weir on a clarifier is to provide a means for leveling the weir.

   a. True
   b. False

5. Overflow weirs are used to:

   a. Measure the flow of sewage
   b. Retain the scum
   c. Permit discharge of storm water
   d. Provide even distribution of flow through units

6. What is the discharge of a 9" Parshall Flume if the head is 5 3/8"?

   a. 260 gpm
   b. 116.9 gpm
   c. 219.9 gpm
   d. 404 gpm

7. What is the discharge over a 90° V-Notch weir with a head of $7\frac{1}{2}$ inches?

   a. 21.7 gpm
   b. 338 gpm
   c. 195 gpm
   d. 750 gpm

8. The discharge for water from an open pipe falls toward the ground because of the:

   a. Velocity of the water
   b. Volume of the water
   c. Pull of gravity

9. What is the average gallon/minute flow if the daily total flow is 0.5 MGD? (omit fractions of 1 gallon)

   a. 347 GPM
   b. 354 GPM
   c. 362 GPM

10. If 75% of the daily flow of 1,000,000 gallons of wastewater is discharged to the lagoon between 6:00 a.m. and 10:00 p.m., what is the average flow per minute to the lagoon during the remaining hours of the 24 hour day? (omit fractions of 1 gal) Which of the following answers is most nearly correct?

    a. 400 GPM
    b. 460 GPM
    c. 520 GPM

CHAPTER VI

IMHOFF TANKS

CHAPTER VI

Imhoff Tanks

Purpose

Ordinarily, where Imhoff tanks are used, they serve as the sedimentation and sludge digestion facilities for the primary treatment of the sewage and may precede a lagoon system that provides secondary treatment.

Theory

The Imhoff tank is a two-story structure--an upper compartment in which sludge digestion occurs. A trapped slot between these compartments provides a means for solids which settle from the sewage in the upper chamber to pass into the sludge digestion compartment. This trapped slot also prevents gases, resulting from decomposition in the digestion compartment, together with the gas-lifted particles of sludge, from rising through the settling compartment and interfering with the sedimentation process. These gases and gas-lifted particles are deflected by the sloping bottom of the sedimentation compartment, into the gas vent from where the gases escape; most of the gas-lifted particles settle again if the scum is worked daily. In a properly working tank, the gases given off should be inoffensive with a slightly tarry odor.

Many variations in the design of Imhoff tanks are found, such as the clarigester and spiragester, but all of the designs incorporate the features listed above and accomplish the same purpose. The tanks may be square, rectangular, or circular in shape, have covered or uncovered gas vents, and have one or more settling compartments; also they may be so designed that the direction of flow through the settling compartments can be reversed.

Design and Loading

The desired loadings of Imhoff tanks are as follows:

1. Average detention time should be 2 hours.
2. Maximum weir loading should not exceed 15,000 gallons/ft. of weir/day.
3. Capacity should be at least 4.0 cu. ft./capita.
4. If industrial wastes are present, population equivalent of the industrial waste should be added to the number of persons served in order to determine the population served for calculating the sludge compartment capacity.
5. The average overflow (surface loading) rate should not exceed 600 gallons/sq. ft./day and the maximum rate should not exceed 900 gallons/sq. ft./day.
6. The scum chamber or gas vents should have an area of from 20 to 30 percent of the surface area of the tank.

Settling Compartment

1. Grease, scum and floating material such as sticks and matches should be removed daily. This can be done by the use of a skimmer. Such grease and scum should be disposed of promptly either by burying, burning, or by placing in the gas vent and mixing with the floating solids.
2. The sides and slopes of the sedimentation compartment should be scraped carefully with a squeegee so that all solids are pushed down through the slot. This should be done at least once a day, taking care so that no solid material will be stirred up and pass from the tank.
3. The slot in the bottom of the sedimentation compartment must be kept

open and free from obstruction of any kind. If the squeegee cannot be pushed through the slot, it will be necessary to clean the slot by dragging a chain through it, using an up and down, saw-like motion.

4. Clean the effluent weirs at least once a week by scrubbing with a stiff bristled brush.

5. Reverse direction of flow in reversible flow settling compartments every two to three weeks if length of compartment exceeds 35 feet. It is recommended that the flow be reversed at a time during the day when the flow to the plant is at its minimum.

6. Failure to carry out the foregoing operation procedure usually will result in an effluent of inferior quality. There will be a heavier load on the stabilization pond secondary units which will result in a poor quality of effluent; also deposits and accumulation of solid materials such as grease, scum or sludge, will add to the work involved in the usual operation of the plant.

Gas Vents

1. The scum in the gas vent should be broken and mixed every day to afford an easy escape for the gas from the sludge digestion compartment and to prevent breeding of flies. Scum control can be accomplished in one of the following ways:

   a. Breaking the scum with a hoe.

   b. Hosing the scum in the gas vents with water under pressure, if the water is available. A small pump in the final settling basin (if available) provides water for this purpose in a number of secondary treatment plants.

c. Installing an air compressor and a number of pipe extending 4 to 5 feet below the liquid level in each gas vent.

2. Gases produced by the sludge digestion process are highly combustible; therefore, precautionary measures should be observed to guard against explosion.

Sludge Compartment

1. In order to know the rate at which sludge is accumulating, it is necessary that the depth of the sludge be measured at intervals not exceeding two weeks. The sludge depth should be measured at both the inlet and outlet ends of the tank.

   a. One method of determining the depth of sludge is to lower through the gas vent an iron plate or weighted wooden block attached to a wire or chain. The plate or block will stop when the sludge is reached. The distance from the top of the tank is determined from the distance the chain or wire is lowered.

   b. A modification of the above may be used where the condition of gas vents will permit the use of a lighter implement. This consists of a wire loop, 12" or 15" in diameter, covered with a disc of quarter-inch mesh wire. A very light chain should be used with the disc suspended at three points.

2. Removal of sludge.

   a. Sludge should be drawn to a sludge bed whenever the sludge depth approaches within 24" of the slot in the sedimentation compartment. This distance can be determined from the plans for the Imhoff tank

or approximately by measuring the depth to the slot in the settling compartment from the top of the tank and adding $2\frac{1}{2}$ feet to the measurement. No more than 40% to 50% of the sludge should be drawn at one time.

b. Digested sludge should be removed in small amounts at frequent intervals rather than in large amounts at longer intervals. During winter months it probably will not be necessary to remove sludge, unless trouble is experienced or the sludge rises to within two feet of the slot. Proper drawing of sludge during the summer and fall, if the Imhoff tank is adequate, will usually provide enough storage space for sludge so that winter time drawing should not be necessary. Sludge should not be drawn in the spring until at least 30 days after gas production has increased over what it was during the winter.

c. Sludge should not be removed unless it is well-digested. A well-digested sludge from an Imhoff tank is black and has very little odor. Undigested sludge is gray or brown and has highly offensive odor; such material should not be withdrawn to the sludge beds. The appearance of gray sludge is evidence that too much sludge has been withdrawn and the sludge line valve should be promptly closed. Some digested sludge should be left in the sludge compartment in order to assist in the digestion of the remaining undigested sludge. Usually less than half of the sludge present is removed; the quantity removed is determined by the sludge soundings and appearance of the sludge.

d. Sludge should be removed at a slow regular rate to avoid the formation of a channel through the sludge in the sludge compartment which results in the withdrawing of partially digested sludge, or the liquid above the sludge. When sludge is first drawn, it is a good plan to partly open and close the sludge line valve so the sludge flows at a slow regular rate; then close the valve for a few minutes. This should be repeated several times in order to obtain a uniform movement of the digested sludge.

e. After the sludge has been removed, and if water is available the riser pipe should be flushed with water to prevent the sludge from caking.

General

All concrete side wall surfaces and walkways above the water level should be kept free of grease accumulations and any other forms of foreign matter which may be splashed or dropped on them during routine care of the tank. The surfaces should be washed if water under pressure is available. A stiff bristled brush can be used if water under pressure is not available.

Failure of Sludge to Flow Readily

1. Causes.

   a. Clogged sludge draw-off piping by caked sludge in pipe.

   b. Accumulations of sand and silt in sludge compartment.

   c. Sticks, rags, and weeds caught around supports for sludge draw-off piping in bottom of tank.

   d. Sludge extremely heavy due to failure to withdraw at frequent enough intervals.

2. How to start a flow.

   a. By agitating with water under pressure through a pipe perforated at the lower end. The pipe should be lowered to the bottom of the sludge draw-off pipe.

   b. By agitating with water under pressure with compressed air or a combination of both through a pipe perforated near the lower end. The pipe should be lowered to the bottom of the sludge draw-off pipe.

   c. By applying compressed air to a pipe with a return bend on the lower end lowered to near the bottom of the sludge draw-off pipe.

   d. By closing the effluent pipe from the Imhoff tank and developing additional head.

3. After determining the cause of sludge not flowing, steps should be taken to prevent it from recurring in the future.

Foaming of Imhoff Tanks

Foaming is a term used to describe the condition which sometimes develops in Imhoff tanks whereby gas, froth and scum rise in the gas vent. The scum may be carried over the wall into the sedimentation compartment and over the outer wall onto the ground.

Besides being unsightly and disagreeable, this condition seriously interferes with the efficiency of the plant. The causes of foaming may be attributed to industrial wastes such as milk or cannery wastes, drawing too much sludge at one time, or increased temperatures in the sludge compartment. Foaming is frequently associated with an acid condition of the sludge, and in such cases,

can be minimized or corrected by treatment to counteract the acidity.

Some of the more simple corrective and control measures are as follows:

1. Relief may be obtained by drawing some sludge if well-digested sludge is available. This practice will, however, usually do more harm than good. Foaming occurs when digestion is being established after it was stopped. Therefore, drawing sludge will usually remove the seed and/or buffering material... then digestion will again have to become established and foaming will probably recur.
2. Hosing the gas vent area with water under pressure will help sometimes.
3. Paddling the foam with long handled hoes is also temporarily effective.
4. Hydrated lime, added through the gas vents at a rate of about 10 pounds per 1000 population, will frequently correct foaming and aid in maintaining the pH value of the digesting sludge at about 7.0. Liming may be necessary several times over a period of 2 to 3 weeks. Lime should be applied in the form of a slurry. Lime applied in dry form may settle directly to the bottom without becoming thoroughly mixed with the contents of the digestion compartment.
5. Treatment of raw sewage with chlorine, at rates of 20 to 50 pounds per million gallons, will give relief in some instances.

Freezing of Scum in Gas Vents

Freezing of scum in the gas vents results in a great increase in the thickness of the scum layer and prevents gas from escaping. Gas vents should be worked every day. During extreme cold weather, it may be advisable to cover the vents during the night with tar paper or wooden planks but this does not

eliminate the need for or take the place of the routine care of the gas vents previously mentioned.

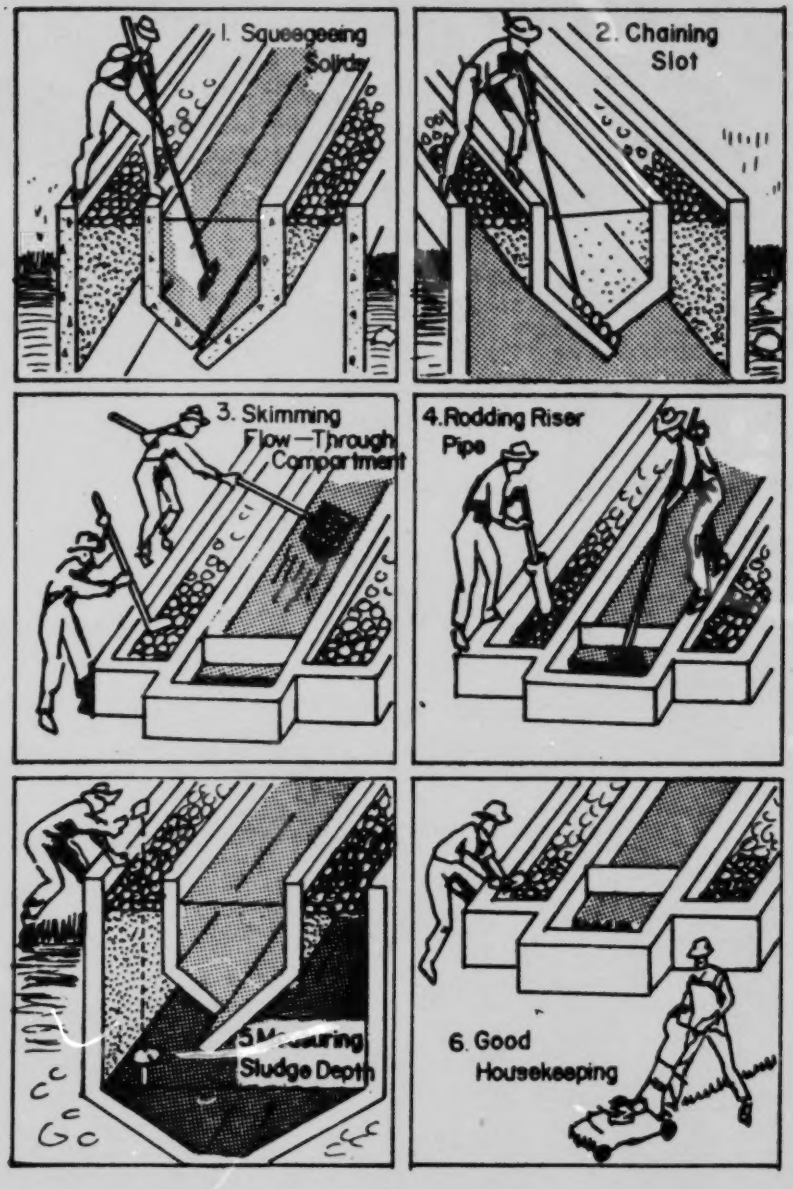
Tests for Performance

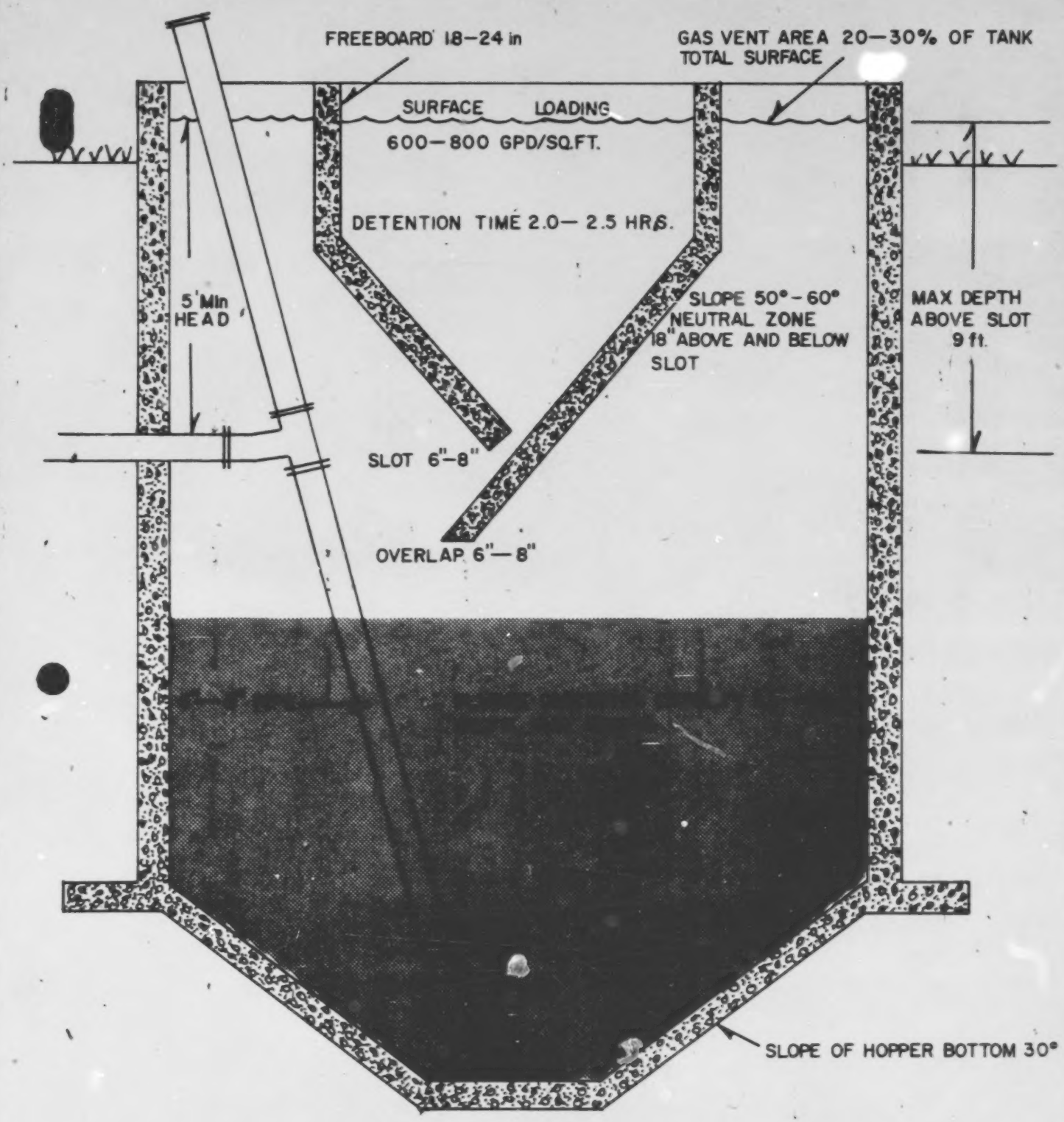
Tests for settleable solids, B.O.D., suspended solids and pH will usually keep the operator informed as to how well the tank is functioning.

Records

1. Dates of skimming settling compartment.
2. Dates of breaking scum in gas vents.
3. Dates of squeegeeing sides and sloping bottom of settling compartment.
4. Dates of cleaning slot with chain.
5. Dates of cleaning weirs.
6. Depth of sludge in sludge compartment at inlet and outlet end of tank (twice a month).
7. Dates and volume of sludge drawn as determined from depth of wet sludge on drying beds.
8. Difficulties --nature of trouble, date noticed, type of correction made, action taken to prevent recurrence.

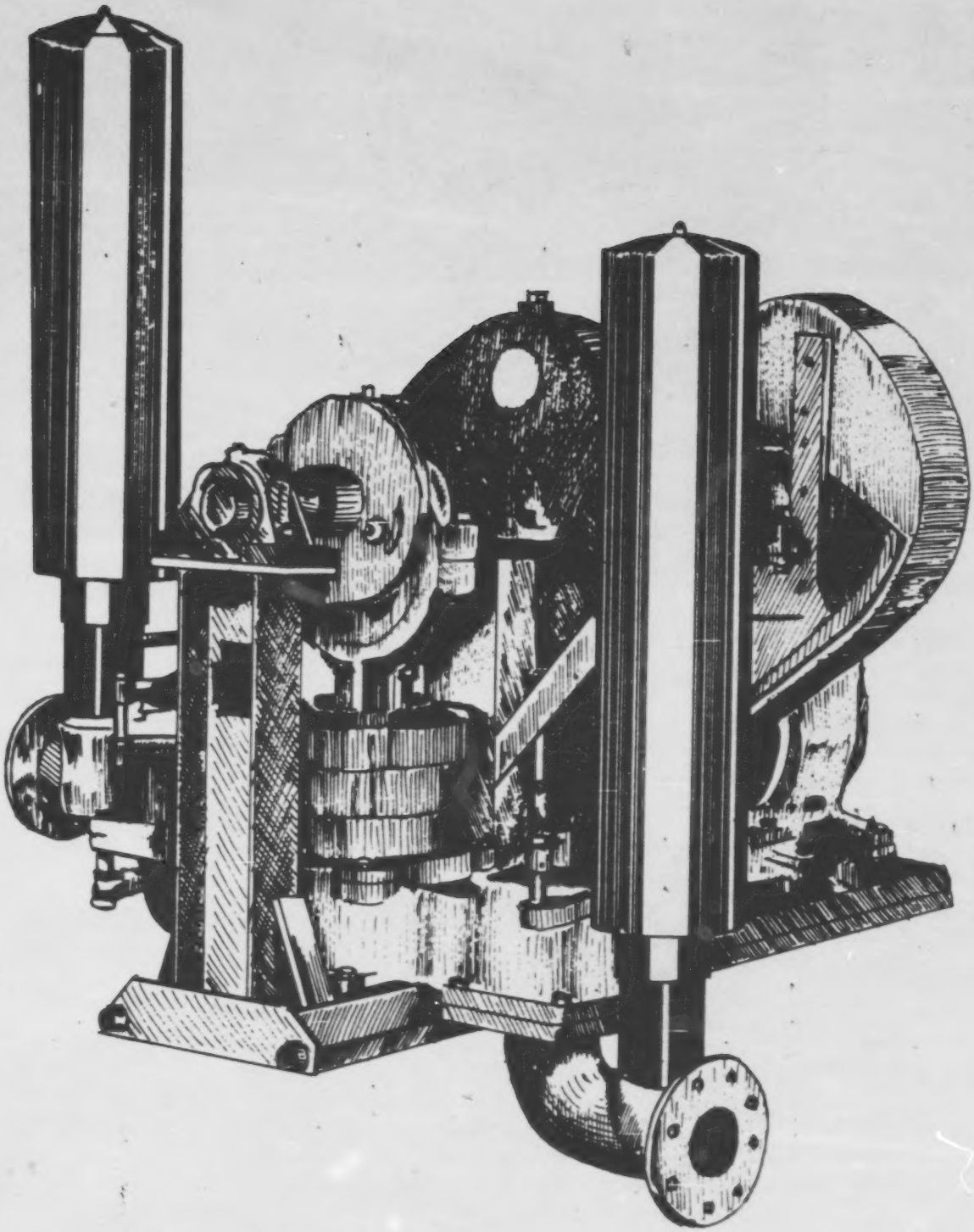
IMHOFF TANK MAINTENANCE





GENERAL DESIGN CRITERIA

VI-11



RECIPROCATING SLUDGE PUMP

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D E
7. A B C D
8. A B C D
9. A B
10. A B C

EXAMINATION QUESTIONS

Imhoff Tanks

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter VI, Imhoff Tanks. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. The slot or slots in the bottom of the sedimentation chambers of Imhoff tanks must be kept open and free from obstructions of any kind. This can be done by:

   a. Removing the slots and scraping them
   b. Dragging a chain through the slots
   c. Reversing the flow
   d. Using a scum hoe

2. The best method of maintaining the gas vents of Imhoff tanks in good operating order is to

   a. Add lime regularly to keep vents clean
   b. Reverse the flow in the Imhoff tank
   c. Break up scum daily with a suitable tool
   d. Wash off with chlorine

3. The floating solids in the settling chamber of an Imhoff tank should be:

   a. Burned daily
   b. Measured daily
   c. Chlorinated daily
   d. Skimmed daily

4. The walls of the settling compartment of an Imhoff tank should be:

   a. Cleaned or squeegeed regularly
   b. Rodded regularly
   c. Skimmed regularly
   d. Chipped regularly

5. In withdrawing sludge from the sludge digestion compartment of an Imhoff tank or digester, it is necessary to allow some sludge to remain in order:

   a. To prevent overloading the drying beds
   b. To provide a seed material for raw sludge added to the digester
   c. To prevent the tank from caving in
   d. To prevent the plugging of sludge pipes

6. The Imhoff tank is a two-story unit. The upper compartment serves as the settling tank and the lower compartment provides space for

   a. Gas vents
   b. Digestion of solids
   c. Skimming chamber
   d. Reserve tank
   e. Chlorinating of influent

7. Sludge discharged from the digestion compartment of an Imhoff tank or sludge digester to a drying bed at a certain plant had a strong, nasty odor, did not drain well, and became a breeding place for large number of flies. This condition

   a. Showed the sludge to be improperly digested
   b. Showed the sludge to be digested too much
   c. Was caused by an excess of lime in the sludge
   d. Was caused by an overheated digestion compartment

8. The overlapping slot construction in the bottom of the settling channel of an Imhoff tank serves mainly to:

   a. Prevent the escape of heat from the sludge digestion compartment
   b. Prevent large objects from dropping into the sludge digestion compartment
   c. Prevent gas and scum rising from the digesting sludge from entering the settling channel
   d. Increase the structural stability of the tank

9. The greater part of sludge digestion in an Imhoff tank is accomplished by what type of organisms?

   a. Aerobic
   b. Anaerobic

10. Based on minimum requirements, what is the approximate capacity in gallons of an Imhoff tank designed to serve 1,000 domestic users? (Assume that no industrial waste is to be treated)

    a. 10,000 gallons
    b. 30,000 gallons
    c. 40,000 gallons

CHAPTER VII

WASTEWATER STABILIZATION PONDS

CHAPTER VII

Wastewater Stabilization Ponds

Purpose

Lagoons were used as far back as 800 B.C. in Persia. The terms "lagoon", "oxidation ponds", and "stabilization ponds" have all been used somewhat interchangeably for all types of earthen ponds incorporated into wastewater treatment units. In order to clarify the technical names given in this manual the following terms should be observed.

Ponds receiving raw sewage and particularly those formed by the construction of dams across ravines and natural depressions in the earth whose shape, depth, and marginal area are not controlled, are classified as "lagoons".

Ponds of regular and controlled shape, depth, and marginal area, specifically designed and constructed as a secondary treatment device for domestic sewage, are "stabilization ponds", or "oxidation ponds".

The term "stabilization pond" will be used in referring to all ponds or lagoons designed and constructed for the purpose of receiving and treating domestic wastewater.

In any given community or facility, the purpose of a stabilization pond is the same; this is to settle out the settleable solids and oxidize the larger portion of the suspended solids present in wastewater.

Theory

Under controlled conditions, microscopic life present in the stabilization pond utilizes three distinct processes to produce a stable effluent. An effluent of acceptable quality will normally be saturated with dissolved oxygen, and this

in turn eliminates odor problems. These three processes are photosynthesis, respiration, and bacterial decomposition.

Photosynthesis

Many of the microscopic organisms present in stabilization ponds are related to the plant kingdom, which contain chlorophyll within their cells. Chlorophyll, along with the energy provided by sunlight, is used by plants to synthesize carbohydrates from carbon dioxide and water. The process of photosynthesis is regarded as occurring in two separate stages. The first is the absorption of light by chlorophyll. This causes a separation of the water molecules into an oxidizing fragment called hydroxide (OH). This will become oxygen (O), and a reducing fragment called hydrogen (H). In the second stage, the reducing fragment is used to reduce carbon dioxide (CO_2) to plant carbohydrates.

Simply stated, the microscopic plants have the ability to combine carbon dioxide and water to form formaldehyde, starch and other carbohydrates. In a properly functioning stabilization pond a dense growth of green algae will develop. In the process of their growth, oxygen is produced as a by-product. This is where the high oxygen content comes from in a stabilization pond. It should be remembered that this process takes place only in the presence of light.

Respiration

Respiration is a life process of microorganisms which is common to both plants and animals. In its broadest sense, the term respiration refers to all the energy-yielding reactions (oxidations) occurring within a cell.

Note: A microscopic plant absorbs its food through its skin or outer membrane, whereas most microscopic animals ingest food through a mouth.

Oxygen is taken in and carbon dioxide is given off. The carbon dioxide will react with the water and carbonic acid will result. The ability to do work within the cells comes from the released energy which appears as heat.

The process of respiration, unlike photosynthesis, goes on in the dark as well as in the light. Animal organisms such as protozoa, rotifera, and fungi, which contain no chlorophyll, do not have the food building ability of photosynthesis and must consume organic food which is readily available to them.

Bacterial Decomposition

Bacteria in wastewater live upon dead organic matter, taking in oxygen and giving off carbon dioxide. If the oxygen is depleted, the bacteria must then derive oxygen from the organic food itself. This results in anaerobic decomposition. If a pond is constructed to a depth greater than 5 feet, the sunlight will not penetrate its full depth and anaerobic conditions will develop.

As in any other treatment process dealing with microscopic life, the operator's main concern is to provide a desirable environment for the organisms.

Design and Loadings

More than with any other treatment unit, design criteria for stabilization ponds will vary from state to state, based on water quality standards for receiving streams.

The site and size of the ponds should, of course, be approved by the governmental control agencies.

Some states will approve plans and specifications for two cell ponds to be used for the complete treatment of wastewater, whereas other states will approve their use for secondary treatment only, with primary treatment preceding the pond.

Where two cell ponds are utilized the primary pond is usually designed on a one acre per 200 population ratio, with the secondary cell three-tenths as large as the primary cell. Where the pond serves as secondary treatment only, a design ratio of one acre per 300 population is normally used.

General Design Guidelines

1. Percolation tests should be made at the elevation of the pond bottom. The rate of percolation should not be more than .25 inches per day. Ponds should not be built where the sewage will seep or percolate through the soil unless plans are made to seal the pond to prevent seepage.
2. The bottom of the pond should be level with no shallow or fringe areas.
3. All debris should be removed before construction.
4. Top soil removed can be used in constructing the dikes if it is impervious or sealed with an impervious material.
5. The dike should have a minimum top width of 8 feet.
6. There should be no islands, peninsulas, or coves to interfere with the circulation or flow.
7. Provision should be made to divert surface water.
8. There should be a slight slope at the discharge end of the pond with a saucer-shaped depression.
9. The inside of the dike should have a minimum slope of 4 feet horizontal to 1 foot vertical.
10. Provisions should be made to prevent vegetation growth on the

pond bottom and the dike below the water line.

11. Timber should be removed to a distance of 500 feet to enable the wind to blow across the pond, and so leaves will not be a problem. Wind action across a pond will help to spread the settleable solids and prevent solids from building up around the intake. Wind also provides a natural aeration process.

12. Provision should be made to keep flood water from backing up into the pond.

13. The end of the discharge pipe should rest on a concrete slab.

14. Some type measuring device should be provided so the depth of the pond can be observed and recorded.

15. There should be a 2 foot minimum and a 3 foot maximum depth on ponds up to ten acres in size.

16. On ponds over ten acres in size, a minimum depth of 2 feet and a maximum of 5 feet should be maintained.

17. A flow measuring device should be provided.

18. The pond should have a freeboard of 2 to 5 feet above the water level.

19. The dike should be rip-rapped with rock, stone, boulders, etc., to prevent erosion from wave action.

20. The outer slope should be gradual and should be sodded to prevent erosion from heavy rainfall. The gradual slope will permit the use of power mowers to keep the weeds and grass under control.

21. The inlet pipe should be submerged and enter the pond in a manner that will facilitate the quick mixing of the incoming sewage with the water in the pond. This is sometimes done by installing a baffle wall

to spread the incoming sewage over a greater area. This will prevent short circuiting, a condition that allows the incoming sewage to flow directly to the discharge.

22. Pond outlets should be one of three types. The first type employs a large diameter pipe set vertically. This pipe is joined to the horizontal outlet pipe which extends through the dike by means of a tee. No floating material should pass through the pond effluent pipe. This problem is solved by the use of surface baffles surrounding the vertical pipe. Construction in this manner keeps the floating solids on the baffles' outside edge; only the water passing beneath the baffle is allowed to overflow into the discharge pipe. The horizontal pipe on the bottom is for draining pond for maintenance. (See Drawing on Page VII-10)

The second type of outlet should accomplish the same results as the first. This method employs a surface baffle placed just ahead of a weir. The water must pass beneath the baffle and then flow over the weir. The weir should be constructed in a manner that will allow an even flow over it. (See Drawing in Chapter V, Page 6)

A third type of discharge outlet incorporates the use of a telescoping discharge pipe. The main advantage is that it allows discharging the pond effluent from various levels. (See Drawing on Page VII-9)

23. In some areas stabilization ponds may be constructed with sufficient surface area to dispose of the water by evaporation. In this type of pond it has been found advantageous to extend the submerged inlet pipe to a point near the center of the pond.

Anaerobic Stabilization Pond

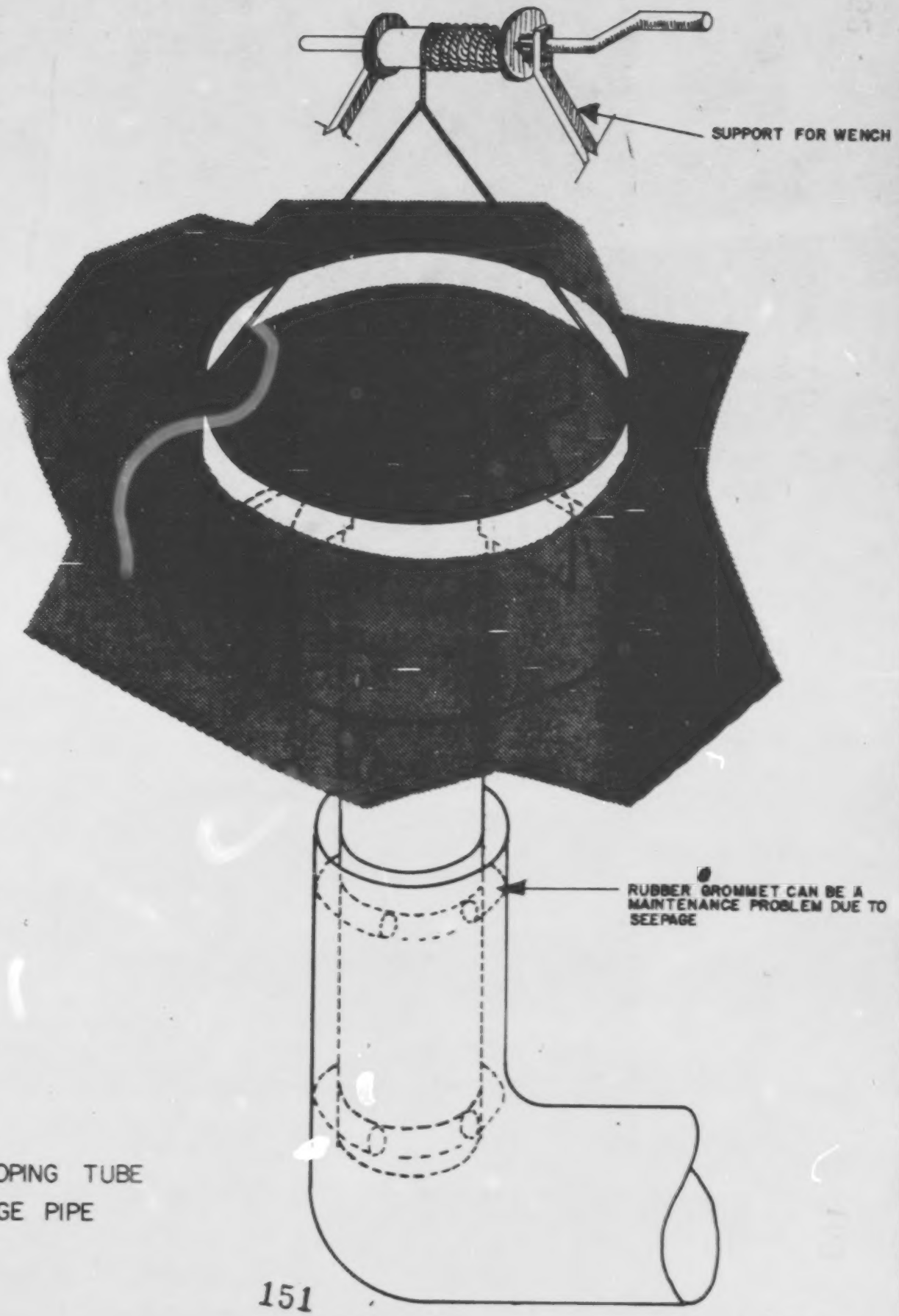
This wastewater treatment process is being used more frequently in recent years, especially for pretreatment of highly concentrated organic waste discharged from food processing plants,feedlots for live stock, and large facilities for egg and poultry production.

Usually the anaerobic pond is operated at much greater depth than a conventional naturally aerated stabilization pond. The more shallow anaerobic ponds appear to perform efficiently but require additional surface area in order to provide the desired retention time. At some locations this additional surface area is not readily available, therefore, it is more practical and economical to construct an anaerobic pond of considerable depth.

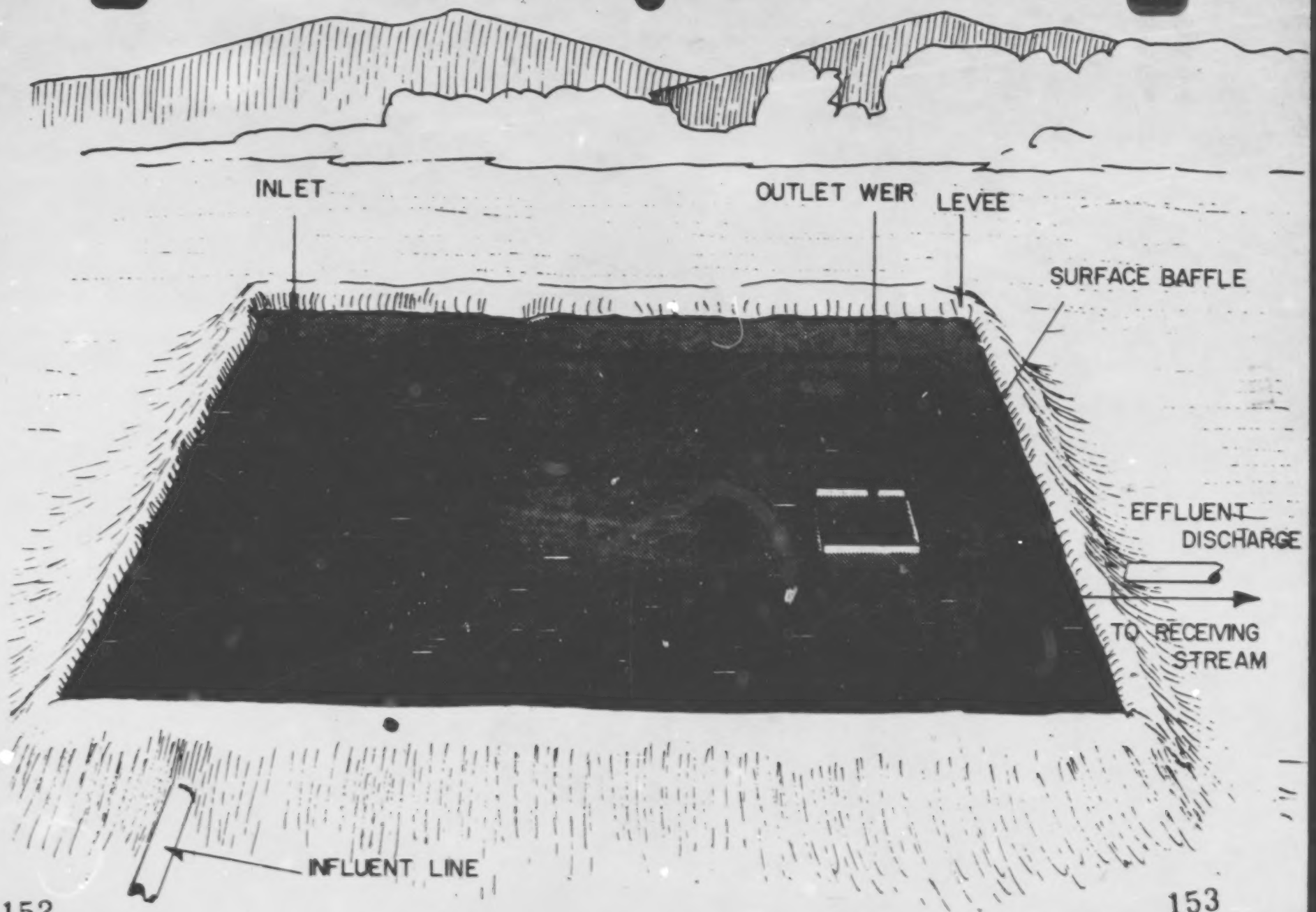
Obnoxious odors from the anaerobic pond appear to minimal after the pond is once filled and normal operation is attained. In normal operation, a heavy mat or blanket forms on the surface of the liquid content of the pond. This is considered to be beneficial to the operation of the anaerobic pond and has been induced and facilitated by spreading floatable material such as chopped straw to the pond surface.

Further pretreatment, apparently very effective, has been provided at some locations by routing the effluent from the anaerobic pond to one or more units of a mechanically aerated pond. There, further B.O.D. and suspended solids reduction is accomplished as the desired dissolved oxygen content is provided. Adjustment of pH may or may not be required depending on the characteristics of the wastewater and the capability of the receiving treatment plant.

Reductions of as high as 50% of B. O. D. and suspended solids have been reported by this type of facility. Apparently, no serious problems have been encountered by the receiving plants in accepting and providing final treatment for wastewater that has been adequately pretreated by the anaerobic pond process.



TELESCOPING TUBE
DISCHARGE PIPE


INLET
OUTLET WEIR
LEVEE
SURFACE BAFFLE
EFFLUENT DISCHARGE
TO RECEIVING STREAM
INFLUENT LINE

152

153

General Loading Practices

It has been found that one acre of surface area will stabilize 35 pounds of B.O.D. per day without creating a nuisance or objectionable odors.

To find the surface area required for á community the B.O.D. load in pounds per day should be determined. This may be done by actual test or by using the national average of 0.17 pounds per person per day where only domestic sewage is to be treated.

Example 1.

If a community has a population of 2000 people contributing an average of 0.17 pounds of B.O.D. per capita per day:

2000 x 0.17 = 340 pounds total B.O.D.

340 ÷ 35 = 9.7 acres of ponds needed.

Example 2.

If that same community had primary treatment ahead of the stabilization pond the primary units should remove at least 35% of the total B.O.D.

2000 x 0.17 = 340 total B.O.D.

.35 x 340 = 119 removed in primary treatment

340 - 119 = 221 to stabilization pond

221 ÷ 35 = 6.3 acres of ponds needed.

If the above pond had a controlled depth of 3 feet and with an average flow of 100 gallons per person per day, this would give a detention time of about 30 days.

Maintenance and Operation

While around the clock operating attention is not required at stabilization

ponds, they must, however, receive a certain amount of attention and maintenance if good results are to be obtained. Daily inspections are best and at least weekly tests and inspections are required for anything like suitable results.

It is essential to keep the dikes and surrounding area free from weeds, brush and other obstructing vegetation. The growth of cattails and other shallow water plants should also be prevented. Some municipalities control the vegetation on the dikes with an adequate number of livestock. Sheep are the best as they like weeds, willows, etc., but stray dogs will sometimes attack them. Where cattle are used, only calves or steers should be used. Horses should not be used as they do not graze the entire area but only an area which is large enough to furnish short tender grass.

Where chemicals are to be used in controlling cattails or other vegetation, the state conservation department should be contacted for their approval on the chemical and the method of application.

Any large floating objects that might accidentally get into the pond should be removed as they may become an obstruction in the pond outlet.

Although the operation and maintenance of stabilization ponds consists mainly of keeping embankments in good repair and cleared of growths of vegetation, sometimes septic conditions develop in certain areas. This may be caused by long periods of cloudy weather, such as in winter. One of the methods for correcting this condition is the use of sodium nitrate. An original application of 200 pounds sodium nitrate per million gallons will usually stop the odor. It may be necessary to repeat this with a reduced application of one-

half to one-fourth the original application each succeeding day depending on the weather. The day time D. O. should not be below 3 mg/l.

Equipment Utilized

1. Laboratory equipment - for conducting tests.
2. Mower - for keeping weeds and grass mowed.
3. Burning equipment (butane) - for burning weeds on steep banks where mower cannot be used.
4. Boat and outboard motor - to aerate and stir up pond - also break up drifts.

Results to be Expected

A well operated stabilization pond will remove 85% to 90% of the B. O. D. The reduction of bacteria will be 90% or better.

Difficulties Frequently Encountered

There are a few problems encountered in the operation of a stabilization pond. Some of these problems are as follows:

1. During the mid-summer months, certain blue-green algae are blamed for the very foul "pig pen" odors from a pond.
   a. Causes- Blue-green algae sometimes develop into large masses sufficient to form large drifts (blooms). The foul odor develops at least in part as products of decomposition when the algae die off.
   b. Remedies - The growth of blue-green algae can be controlled by a routine practice of treating the lagoon with three applications of copper sulfate. If the total alkalinity is above 50 m/l, apply uniformly ten pounds of copper sulfate per million gallons liquid. If the alkalinity is below 50 m/l reduce the amount of copper sulfate to five pounds per million gallons.

2. Septic conditions can develop producing rotten egg odors.

   a. Causes - Septic conditions are usually caused by the absence of sunlight, such as several days of cloudy weather or when the pond is frozen over with snow. This causes photosynthesis to cease.

   b. Remedies - This odor can be controlled by applying sodium nitrate to the pond. The bacteria use the oxygen from the nitrate as their oxygen supply to maintain aerobic conditions. 200 pounds of sodium nitrate per million gallons will usually stop the odors.

3. Mosquito breeding is a problem in some ponds.

   a. Causes - Still waters are the best place to breed mosquitos.

   b. Remedies - The best way to control mosquito breeding is to control the growth of vegetation at the edge of the water. Burning at the water line is most satisfactory. The absence of vegetation will allow wave action to the bank and prevent the mosquitos from hatching out. Stocking the lagoon with gambusia fish helps control mosquitos.

4. Midge flies are a nuisance in some ponds if not controlled.

   a. Causes - Midge flies normally lay their eggs close to the pond edge. The eggs hatch and larvae migrate into the bottom. It is necessary to have an anaerobic sludge condition for them to feed on until they develop into flies and come to the surface to fly off (usually by the millions). There is one type of midge fly that adapts itself to fresh water. This is the so-called blood worm found in some water reservoirs where chlorination is not practiced.

b. Remedies - The best method of control is to stock the pond with gambusia or other species adapted to the pond environment.

5. Muskrats must be controlled in ponds because of the damage they do to the dikes.

   a. Causes - The damage muskrats may do is a by-product of their den building activities. They burrow under water, but the den or home is above the water line in the bank. If the water level rises and remains high the muskrat will burrow upwards and construct a new den. The muskrat may dig to the surface or may come so close that the top caves in easily. This may endanger the pond dike.

   b. Remedies - Eliminating muskrat food plants is good pond protection. The starchy plants muskrat prefer such as cattail and burr reed should be controlled. Trapping with steel traps is the most efficient way of removing muskrats. Where possible the stake to which the trap chain is attached should be placed in water at least a foot deep so that the captured animal will drown. Otherwise, the muskrat is likely to twist its leg off and escape. The state conservation agent should be contacted before trapping the muskrat.

6. Snakes such as water moccasins and cotton mouths are a problem in some areas.

   a. Causes - Snakes will usually appear from time to time in any pond, but will not normally stay very long or become infested if the pond is kept clean of vegetation around the dikes.

b. Remedies - Snakes can be controlled by throwing several china eggs in the pond. As the eggs disappear, so do the snakes.

Test of Performance

It is necessary to make certain operation control analysis to determine if the environment in the stabilization pond is desirable. These analyses are dissolved oxygen, temperature, pH, alkalinity, B.O.D., and C.O.D.

Results to be Expected

1. D.O. - Effluent 4-14 ppm
2. Temperature - will change with climatic conditions
3. pH - 7.2 - 10.5 in effluent
4. Alkalinity - Normal carbonate and bicarbonate
5. B.O.D. - (Influent 180 ppm - 250 ppm) (effluent 20 ppm - 30 ppm)
6. C.O.D. - (Influent 400 ppm) (effluent 100 ppm)
7. Coliform bacteria reduction of 99%

Records

1. Flows to and from pond (monthly report to state)
2. Maintenance to pond
3. Chemicals used
4. Condition of pond (daily)

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C D
2. A B C D
3. A B
4. A B C
5. A B C
6. A B C
7. A B C
8. A B C
9. A B C D
10. A B C D
11. A B C D
12. A B
13. A B C D
14. A B C D
15. A B C D
16. A B C
17. A B C D
18. A B C D
19. A B C D
20. A B C D
21. A B C D
22. A B C D
23. A B C D
24. A B C D
25. A B C
26. A B C D

EXAMINATION QUESTIONS

Wastewater Stabilization Ponds

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter 7, Wastewater Stabilization Ponds. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri.

1. Pick the chemical that can be used to help rid oxidation ponds of areas that are septic.

   a. Calcium sulfate
   b. Sodium chloride
   c. Hydrogen sulfide
   d. Sodium nitrate

2. Which one of the following is objectionable in pond operation?

   a. Sunlight
   b. Short circuiting
   c. Dissolved oxygen
   d. Phosphates

3. Outlets from ponds should not be baffled to prevent floating material from being discharged.

   a. True
   b. False

4. Waste stabilization ponds operate successfully because:

   a. A balance between bacteria and algae breaks down the sewage and converts it into stable products.
   b. The algae does all the digestion of the sewage
   c. All the sewage is digested aerobically

5. Wind action is vital for the successful operation of lagoons when they are used for complete treatment. One of the primary reaons is

   a. It spreads the settleable solids and prevents buildups around the inlet
   b. Keeps odors down
   c. Spreads the algae evenly over the lagoon

6. If the D.O. falls below 3 mg/l in a lagoon, the addition of one of the following is normally helpful in bringing it back to normal operation:

   a. Sodium nitrate
   b. Copper sulfate
   c. 2-4 D

7. In order to prevent loss of circulation in a lagoon the water level should never be lowered below

   a. 2 feet
   b. 4 feet
   c. 5 feet

8. Because of the simplicity of treatment, an operator needs to check a lagoon

   a. At least one time a week
   b. At least once a month
   c. When there is a gripe because it stinks

9. The purpose of ponds is to:

   a. Retain wastewater while it is treated
   b. Provide a surface for evaporation
   c. Grow mosquitos
   d. Ice skate on

10. What form of plant life is needed for the functioning of a stabilization or oxidation pond?

    a. Weeds
    b. Grass
    c. Algae
    d. Cattails

11. Ponds (oxidation, stabilization, or lagoons) are capable of reducing:

    a. Land area and cost
    b. Chloride content
    c. B.O.D. and bacteria
    d. Hardness of the water

12. Multiple depth outlets on the final pond are encouraged so that the effluent may be removed at the depth containing the best quality water.

    a. True
    b. False

13. Microorganisms that are not plants will give off carbon dioxide gas. Carbon dioxide will react with water to form

a. Sulfuric acid
b. Hydroxide
c. Protein
d. Carbonic acid

14. 400 pounds of sodium nitrate would take care of

a. The second application for odor control in a 2,000,000 gallons capacity stabilization pond.
b. The first application for odor control in a 2,000,000 gallons capacity for stabilization pond.
c. The first application for algae control in a 2,000,000 gallon capacity stabilization pond.
d. The first application for algae control in a 6,000,000 gallon capacity stabilization pond.

15. The first step you should take before applying any chemicals for lagoon vegetation control is:

a. Measure as closely as you can the length and width, then multiply by the average depth to obtain the correct number of cubic feet.
b. Obtain the capacity in gallons that the pond contains
c. Check with the state conservation department for approval
d. Buy the chemical in the medium strength range so over-dosing will not be a problem and yet allow the job to be done correctly.

16. Septic conditions in stabilization ponds can happen in the spring of the year in areas where the winters are severe. This is usually due to the slowed down activity of the microorganisms during cold weather, resulting in an organic overload in the spring. Another factor that can cause conditions is:

a. Allowing the alkalinity to rise above pH 7.0 for sustained periods of time
b. Several days of cloudy weather usually caused by the absence of sunlight
c. Allowing the pond level to drop lower than 4 feet

17. Two food plants that will draw muskrats are:

a. Chlorella and oscillatoria
b. Wild lettuce and celery weed
c. Parsley and blackberry vines
d. Cattail and burr reed

18. Mosquito eggs are very delicate and will be destroyed by heavy wave action on windy days. They may also be killed by chemicals or better yet, by eliminating vegetation growth at the waters' edge necessary for their reproduction. If all these measures fail to give the necessary control, one other thing to try is:

a. Apply a dark staining dye to the water
b. Stocking gambusia fish
c. Try to build a large population of frogs
d. Set up a smoke screen twice a month

19. Which of the following animals would be the better choice to control weeds on a dike?

a. Sheep
b. Horses
c. Cows
d. Steers

20. Snakes will eat china eggs thinking they're the real thing. The china eggs cannot be digested and will result in the snake's death. The best way to control snakes is to:

a. Eliminate the conditions that are necessary for their environment
b. Catch them in snake traps
c. Shoot them when they're out in concentrations in the late afternoon
d. Drain the pond for a period of three weeks twice a year

21. What is the difference between a lagoon and a waste stabilization pond?

a. Lagoons normally handle toxic wastes that are difficult for stabilization ponds to treat
b. Stabilization ponds require considerably more sodium nitrate applications than do lagoons
c. Basically they serve the same purpose, only the stabilization pond is a controlled design and the lagoon is not necessarily a carefully designed treatment facility
d. Stabilization ponds were in existence before lagoons

22. Which of the following items may at times cause odor problems in stabilization ponds?

a. Highly aerobic conditions
b. Blue-green algae
c. Green algae
d. A $B.O.D._5$ of 15 ppm

23. Microscopic animals

a. Contain chlorophyll
b. Absorb food through their cell membrane
c. Consume food through their mouth
d. Would die off without photosynthesis

24. Floating drifts or scum is a breeding place for mosquitos and at times promotes blue-green algae growth. Which of the following items should be used to control these drifts?

a. Boat and outboard motor
b. Copper sulfate
c. Sodium nitrate
d. Farm livestock

25. Respiration

a. Is not nearly as important to plants as it is to animals
b. Takes place only in the presence of sunlight
c. Is necessary for microorganisms that contain chlorophyll and by those that do not.

26. If you were required to operate a two cell stabilization pond for a town of 900 people, the primary pond should be approximately

a. 1.7 acres
b. 3.6 acres
c. 10 acres
d. 4.5 acres

CHAPTER VIII

AERATED LAGOONS

CHAPTER VIII

AERATED LAGOONS

PURPOSE

The purpose of a lagoon is to settle out the settleable solids and oxidize the larger portion of the suspended solids present in wastewater.

From a facilities standpoint waste stabilization lagoons are rather simple, but from a physical, chemical, and biological standpoint, lagoons are complex treatment systems. The conventional lagoon relies totally on natural phenomena to stabilize the organic matter in wastes. The reliance on this natural phenomena depends heavily on ambient environmental conditions. If the wind blows, the lagoon contents are mixed, oxygen may be transferred either to or from the lagoon liquid. If the sun shines, algae may grow, releasing oxygen that may or may not be needed at the time.

A 1973 report indicates that the conventional waste stabilization lagoon cannot meet the recent Environmental Protection Agency (EPA) requirements. All publicly owned treatment facilities must achieve the equivalent of secondary treatment by July 1, 1977.

Since the system just described is not capable of meeting the new requirements for secondary treatment, the application of new concepts is essential.

One of the new concepts used for the secondary or biological treatment of waste is the aerated lagoon which is described as a basin of significant depth, in which oxygen is furnished by mechanical aeration, and in which the turbulence level is sufficient to provide adequate liquid mixing. As a result of adequate liquid mixing, uniform distribution of the waste and good dispersion of oxygen are achieved. Rapid and efficient waste stabilization results.

THEORY

An aerated lagoon can be considered to be a variation of the activated sludge process which does not return settled sludge. Three phases of biological stabilization occur in the aerated lagoon.

Phase I

Phase I occurs from the inlet of the lagoon through approximately the first one-quarter of the volume of the lagoon. The oxygen demand is very high, with much organic material available and relatively few bacteria present.

Phase II

Phase II begins where Phase I ends and will occupy approximately the volume of the second and third one-quarter sections of the lagoon. In this phase the oxygen demand has decreased, with many bacteria present and little or no original organic material remaining.

Phase III

Phase III starts where Phase II ends. This phase occurs in the last quarter section of the lagoon. The oxygen demand is very low. All internal bacterial food reserves are consumed and the bacteria exists in a starving condition. The bacteria then use other bacteria as food to stay alive. They are operating independently, and have little tendency to flocculate.

SECONDARY SETTLING

Secondary sedimentation is required. For every pound of B.O.D. removed, approximately 70 pounds of solids are created. The solids consist of mostly dead bacteria.

DESIGN AND LOADINGS

The depth of aerated lagoons usually varies from 10 to 20 feet but most are designed for a liquid depth of around 10 feet. There should be a freeboard of about 3 feet. The detention time usually varies from 5 to 10 days depending upon the characteristics of the waste and the degree of treatment required.

The lagoon may be aerated with surface mechanical aerators or it may be aerated with subsurface diffused air. In any case, the lagoon liquid must be provided with oxygen to satisfy the biological oxidation demand, and also maintain a D.O. concentration of 1-2 mg/l.

The efficiency of an aerated lagoon depends upon the adequate dispersion of oxygen and organic material. It should be completely mixed, with all solids being kept in suspension.

The pH of the liquid should be between 7.0 and 8.0.

As stated before, frequently, it is necessary to provide secondary sedimentation for solids removal. A conventional clarifier unit is often utilized for this purpose. A surface loading of 800 gallons per day per square foot with a detention of two hours is adequate. Provisions must be made for the removal and treatment or disposal of the sludge. The most economical method of sludge disposal is to provide a sludge lagoon. The sludge lagoon should be at least 10 feet deep with a capacity of several years' accumulation. In some cases it is necessary to pump the supernatant at regular intervals to the plant inlet. In other cases, the supernatant may evaporate.

Some waste treatment facilities utilize a second or even third smaller lagoon behind the aerated lagoon for sludge settling and treatment. In this

lagoon, the aeration is reduced enough to allow the sedimentation of solids but sufficient to keep the lagoon aerobic.

Where two or more lagoons operate in series, the individual air supplies are normally designed to meet the B.O.D. load of each lagoon. For example, if 1000 CFM of air is discharged into the first or main lagoon the air requirements may be only 500 CFM in the second and 250 CFM in the third.

Final effluent is then discharged to a receiving stream or in many cases, disinfected in a chlorine contact basin first, then discharged to the receiving stream.

MECHANICAL AERATORS

Several types of mechanical aerators are presently in use. The major classification is by location with respect to the lagoon water surface. Surface and subsurface are the two classifications.

Surface aerators supply oxygen to the lagoon at or near the water surface by mixing atmospheric air with the lagoon liquid. The surface aerators are further classified by supporting structure into fixed and floating categories. Fixed aerators are rigidly fixed to the lagoon. The water surface is adjusted for proper aerator immersion. Floating aerators, as the name implies, float on the lagoon liquid surface. Cables to the lagoon dikes maintain the aerator in position.

Subsurface aerators supply oxygen to the lagoon by discharging atmospheric air at or near the lagoon floor. Normally a blower is mounted in an enclosure on land adjacent to the lagoon. Through a pipe and valve arrangement air is supplied to diffusers mounted on the lagoon floor. The diffusers are positioned to provide uniform conditions throughout the lagoon.

Normally, mechanical aeration is based on HP (horsepower) rating. Two pounds of oxygen per HP is the average hourly supply rate. Eight HP applied to 1 million gallons of liquid is considered adequate for mixing.

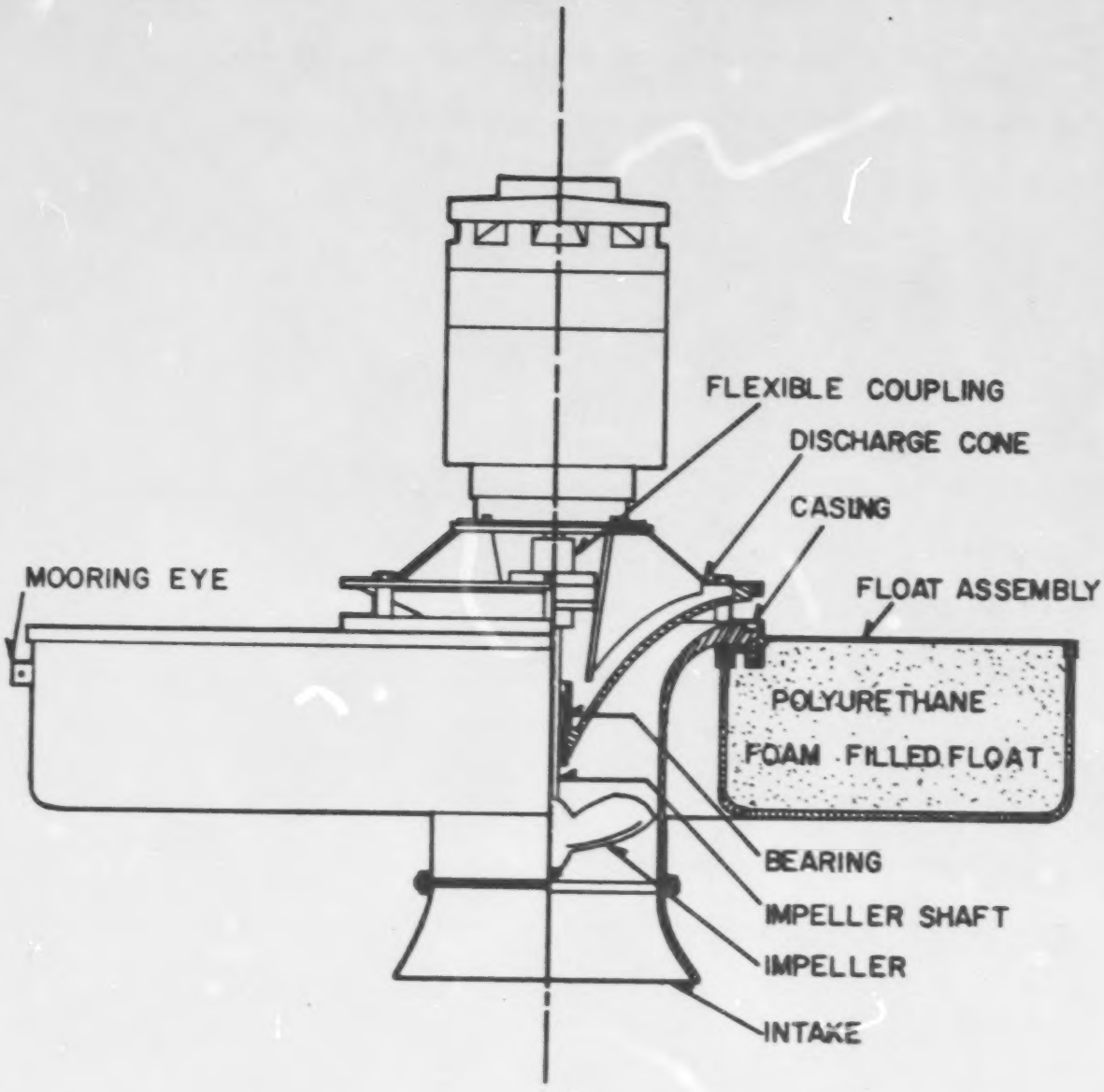
Results to be Expected

A well operated system will remove 90 - 95% B.O.D. The reduction of bacteria will be 90% or better.

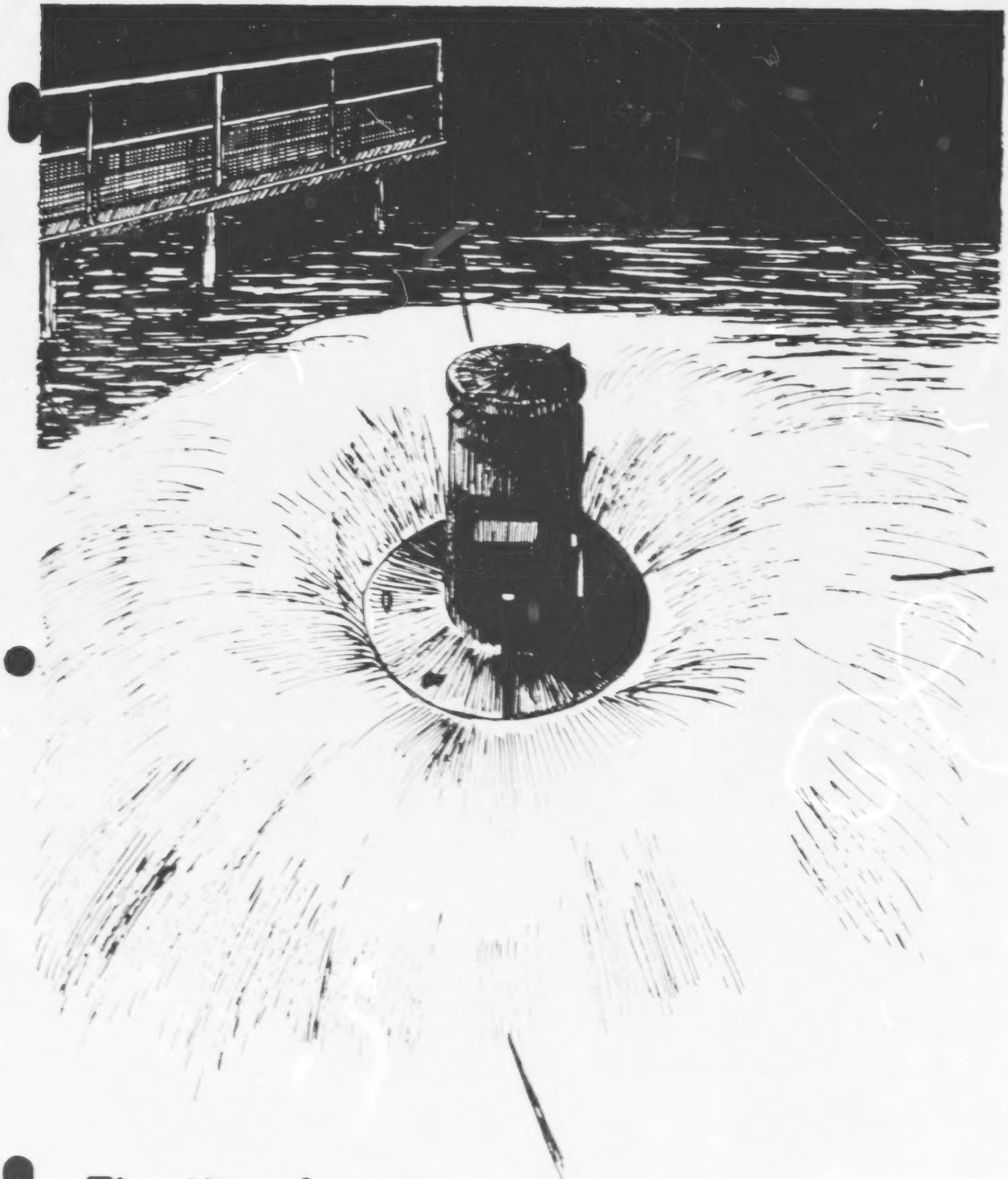
Daily and Weekly Inspection for Surface Aerators

The daily and weekly inspection for surface aeration is about the same schedule.

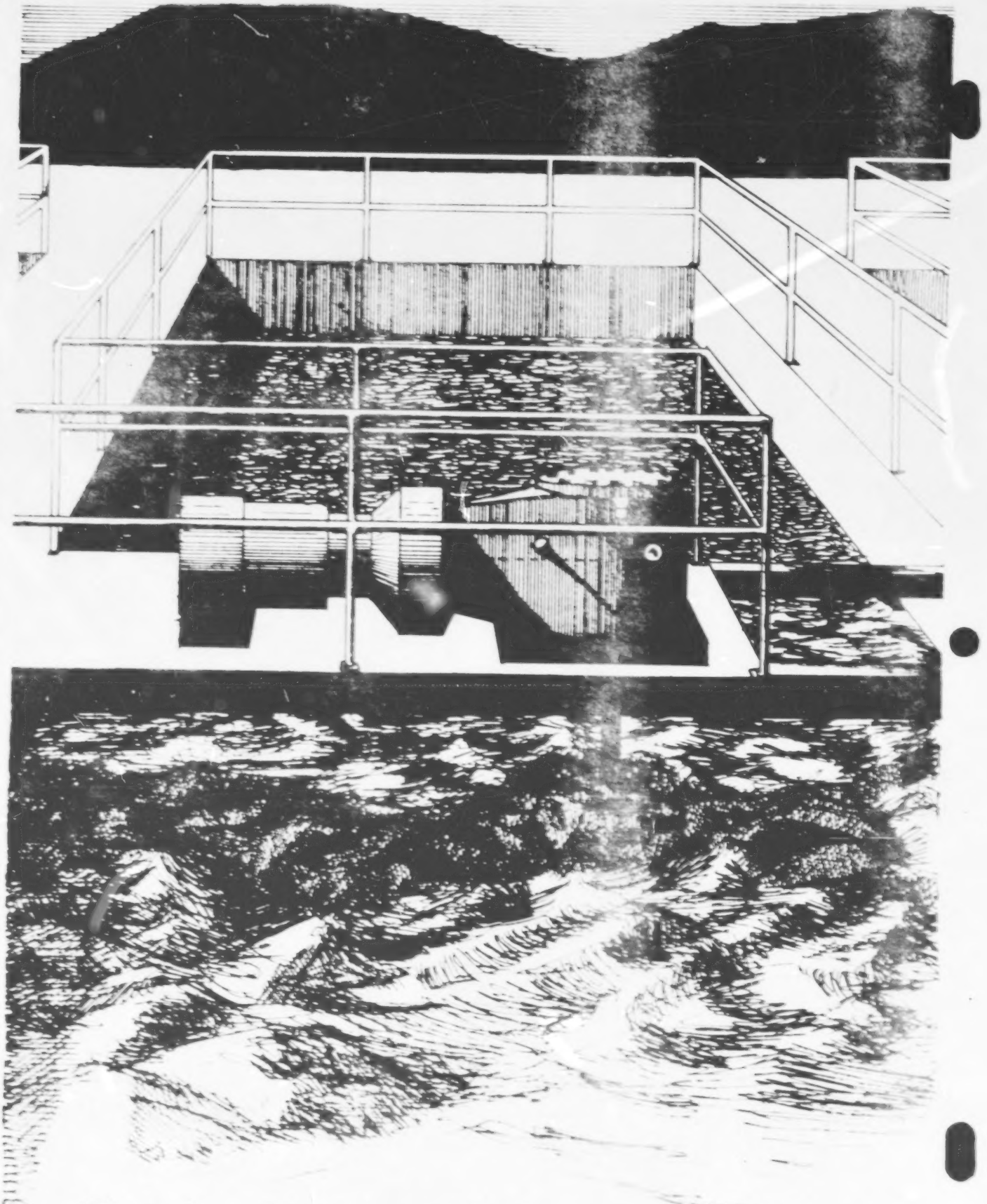
1. Make sure the unit is operating.
2. Lubricate as recommended by manufacturer.
3. Check the suspension cables to see that they are attached.
4. Observe the flow pattern of the pumped liquid.



Cutaway Section of a Floating Aerator



Floating Aerator Unit in Operation



Fixed Aerator Unit in Operation

Weekly Inspection Schedule for Subsurface Aeration

1. Air Filters: Inspect for dirt or obstructions (See manual)
2. Drive Belts: Determine if worn, stretched, or out of line. SEE MANUFACTURER'S MANUAL FOR PROPER TENSION AND SHEAVE ALIGNMENT.
3. Flexible Pipe Connectors: Check for leaks.
4. Relief Valve: Check for required weights or adjustments.
5. Blower House Temperature: During warm or hot weather, the room temperature should not exceed the outside ambient temperature by more than 15°F. Provide plenty of ventilation on warm days.
6. Blower Oil Level: Check carefully after the blower has been shut down for at least one minute. Proper oil level must be kept!
7. Air Pressure: Check to see that it is in the normal operating range. Record reading. Discharge air pressure should never exceed 9.0 psig with a 10-foot water depth. The pressure downstream of gas cleaning unit should be well below 7.0 psig.
8. Gate Valves: Check Operation.
9. Blower and Motor: Check for excessive noise or vibrations.
10. Air Pattern: Observe for leaks in header or tubing. The pattern does not have to be continuous and may vary slightly due to condensate being trapped in the lower levels of the aeration tubing.
11. Airlift: Observe the turbulent surface above the airlift to determine if it is operating.
12. Water Surface: Check for an abnormal amount of dirt, grease, or foreign objects. Skim debris from the surface.

13. Baffles and Dikes: Check for breaks or leaks.

14. Water Level: Check for abnormal level.

Lagoon Reservoir

1. Dikes: Mow grass, remove weeds, maintain banks in orderly condition.

   Caution: Do not let trimmings get into the lagoon.

2. Remove grease, dirt, and foreign matter from the water as often as necessary.

3. Repair inlet and outlet pipes if needed.

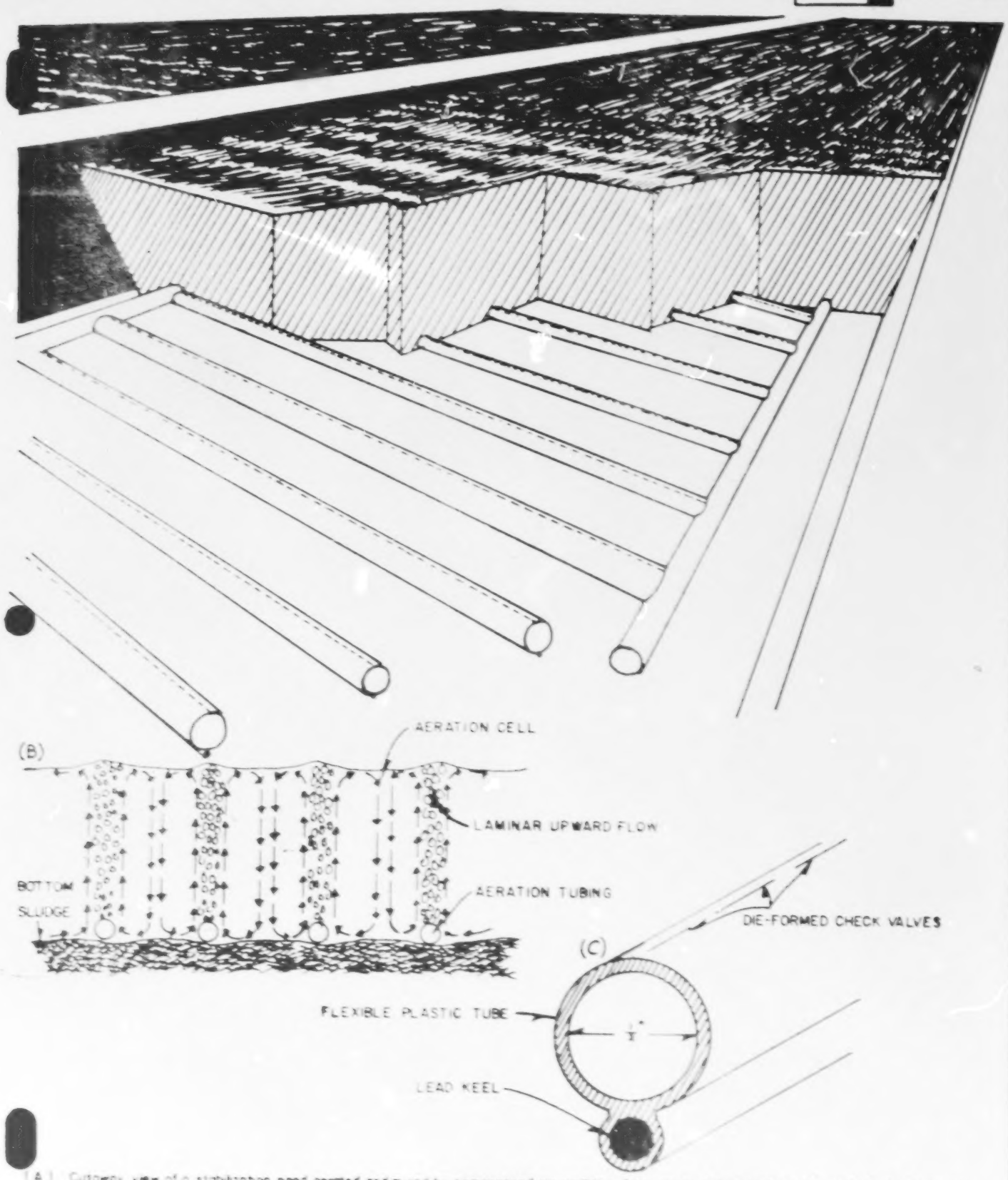
4. Muskrat activity: Look for evidence of muskrats by examining dike for holes, etc.

Operation Equipment Utilized

1. Laboratory equipment - for conducting test.

2. Mower - for keeping weeds and grass mowed.

3. Burning equipment (Butane) (propane fuel oil) - for burning weeds on steep banks where mower cannot be used.



(A) Cutaway view of a stabilization pond aerated and mixed by compressed air emitting from plastic tubing laid on the bottom of the lagoon (B) Schematic of aerating and mixing action (C) Detail of aeration tube

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C D
2. A B
3. A B C D
4. A B C D
5. A B
6. A B
7. A B C D
8. A B

EXAMINATION QUESTIONS

AERATED LAGOONS

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter VIII, Aerated Lagoons. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. The D.O. level in an aerated lagoon should be maintained in the range of:

   a. 4-6 mg/l
   b. 6-8 PPM
   c. 2-4 mg/l
   d. 1-2 PPM

2. The detention time of an aerated lagoon usually is in excess of 30 days.

   a. True
   b. False

3. The pH of an aerated lagoon should be in the range of:

   a. 5-6
   b. 6-7
   c. 7-8
   d. 8-9

4. A well designed and operated aerated lagoon will remove B.O.D. in the following percentage range:

   a. 80-85
   b. 85-90
   c. 90-95
   d. 95-100

5. A well designed and operated aerated lagoon will remove a maximum of 75% bacteria.

   a. True
   b. False

6. A fixed mechanical surface aerator does not require water surface level control.

   a. True
   b. False

7. What is the average hourly oxygen supply rate of a properly operating 15 HP floating aerator?

   a. 15 lb
   b. 15 cu. ft.
   c. 30 lb
   d. 30 cu. ft.

8. 1 HP per 1 million gallons of liquid is considered adequate for proper mixing.

   a. True
   b. False

CHAPTER IX

INTERMITTENT SAND FILTERS

CHAPTER IX

Intermittent Sand Filters

Purpose

Intermittent sand filters are normally used following primary treatment, but in some circumstances where an extremely high quality effluent is required, they are used for polishing effluents from secondary processes such as trickling filters, activated sludge, or oxidation ponds.

The intermittent sand filter strains out and retains on or near its surface, most of the suspended solids carried over from the primary or secondary treatment processes. With normal rates of application, removal of 95% or more of the B.O.D. and suspended solids can be expected.

Theory and Method of Operation

When primary or secondary effluent is applied to the filter bed, the liquid portion will percolate through voids between the sand grains straining out most of the solids on the surface of the sand.

Certain microorganisms, mostly bacteria, which are present in the wastewater, quickly become established in this favorable environment of an ample food supply in the presence of oxygen. In their normal life processes, the organisms convert the organic material to a more stable form. Nitrates will be in the range of 10 to 25 mg/l and some dissolved oxygen will be present.

The essential features of this process are as follows:

1. Sand of adequate depth and quality.
2. A sand bed that will drain well.
3. Uniform distribution of the settled wastewater over the entire surface of the sand bed.

4. Intermittent dosing of settled wastewater, with large particles of matter removed and reasonably free of oils and heavy greases, which would coat the surface of the filter and reduce its efficiency.

5. Drying of the sand surface and then removal of the solids retained on the surface.

6. Replacement of sand which is removed with the solids.

Design and Loading

Intermittent sand filters may be square, rectangular, or circular in shape. When rotary distributors are used, the bed must be circular. Two or more beds are always required, even for small installations, so that one may be rested and its surface dried while the other is dosed. In larger installations, a third bed is needed to allow enough time for cleaning while the second bed is drying. During rainy weather, drying and cleaning may be delayed, so a fourth or standby bed is needed for uniformly good results.

The area for the sand bed is usually excavated to provide a flat slope toward the underdrains. The drains are usually spaced about 10 to 20 feet apart, surrounded by gravel. The drain pipe itself should be at least 4" in diameter, embedded in at least 6 inches of 1" to 2" gravel. Four (4) inches of $\frac{1}{2}$" gravel should be placed over the larger gravel and topped off by at least 2 inches of $\frac{1}{4}$" gravel. Enough gravel should be added to the top layer to compensate for the slope of the floor, so that the top surface of the gravel is level. Usually, the depth of the sand over the gravel is at least 18 inches. Although some beds have as much as 36 inches of sand, very little additional treatment may be expected from the additional depth. Longer periods of time

between replacement of sand removed in the cleaning process is the chief advantage with greater depth. The sand used should have a uniformity coefficient of about 0.2 to 0.5 mm in size. When sand is replaced on the beds, it should be similar to that remaining on the beds for effective performance. Unless the sand is deeper than 18 inches, the loss during solids removal should be replaced when about 3 inches have been removed.

Dosage

Each filter in use should not be dosed more than three times per day, and twice is usually preferred.

The rate of application may vary from about 1 gpd/sq. ft. for septic tank effluent, and from 2 to 4 gpd/sq. ft. from Imhoff tanks, settling tanks, or lagoons and up to about 10 gpd/sq. ft. for secondary treatment. A depth of 2 inches to 4 inches per dose is usually considered desirable.

Solids Removal

When the filter sand bed has drained and the deposited solids have dried enough to be removed with a rake, the crust (thin layer of dried solids) should be removed with rake, fork, or shovel. After this has been done, loosen the sand with a rake or spike-tooth harrow to a depth of 1 inch or more, but do not exceed 4 inches. This helps to promote drainage of the next batch of wastewater and aids in the desirable circulation of air through the sand bed. Care should be exercised to minimize the mixing of accumulated wastewater solids with the sand.

Difficulties Frequently Encountered

Difficulties experienced in the maintenance and operation of intermittent sand filters can usually be traced to one of four things:

1. Continuous Dosing: A leaky siphon which permits a continuous passage of flow should be corrected promptly. Pump controls should be properly set.
2. Vegetation: Keep adjacent areas mowed before weeds go to seed.
3. Dirt: Suitable walls should be maintained in good condition and the earth sodded if necessary to keep dirt from washing into the sand beds.
4. Odors: Over-dosing a filter for prolonged periods may result in odors. Odors also may arise from large quantities of grease and fatty materials.

Chlorination of the settled wastewater before spreading it on the filter will reduce odors. The rate of chlorine dosage will vary widely with the condition of the wastewater, but a dosage of between 5 and 10 mg/l is usually effective in the control of odor.

Records

Records kept on intermittent sand filters should include:

1. Amount of flow to each bed each day.
2. When beds were cleaned.
3. Maintenance to bed or distribution system.
4. Problems encountered.
5. Laboratory tests such as D. O., suspended solids and any others required by the state.

WATER AND WASTEWATER TECHNICAL SCHOOL

EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

GRADE_____ CLASS_____

1. A B C D

2. A B C D

3. A B C D

4. A B C D

5. A B C D

6. A B C D

7. A B

8. A B C D

EXAMINATION QUESTIONS

Intermittent Sand Filters

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter IX, Intermittent Sand Filters. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. In the operation of intermittent sand filters for sewage treatment, it is important to:

   a. Prevent the growth of grass or weeds on the beds.
   b. Rest the beds between applications.
   c. Keep the surface of the beds level.
   d. All of the above.

2. If large amounts of grease or oil are allowed to pass through the treatment process and onto an intermittent sand filter they will:

   a. Be beneficial to the distribution system.
   b. Aid the bacterial activity taking place in the filter.
   c. Coat the surface of the filter and reduce its efficiency.
   d. Cause the filter sand to disintegrate.

3. It is important to keep the surface of an intermittent sand filter level:

   a. To prevent the sand from blowing.
   b. To assure that there is room for the entire contents of the sewage to be filtered.
   c. To prevent channeling as the sewage is applied.
   d. To assure even distribution of the sewage on the filter.

4. The organisms in a sand filter are known to be aerobic organisms. This tells you that they live and multiply:

   a. Only in a nitrate-free environment.
   b. Only in the absence of oxygen.
   c. Only when hydrogen sulfide is being liberated.
   d. Only in the presence of free oxygen.

5. An intermittent sand filter reduces the strength of sewage applied to it.

   a. By biological action only.
   b. By mechanically straining the solids only.
   c. By a combination of mechanical straining and biological activity.
   d. By chemical reaction between the sand and the sewage.

6. The percent B. O. D. and suspended solids removal achieved through an intermittent sand filter should be in excess of:

   a. 95
   b. 97
   c. 98
   d. 96

7. An intermittent sand filter should be dosed 5 times per day or more.

   a. True
   b. False

8. The rate of application to an intermittent sand filter from a lagoon should be:

   a. 3 GPD/sq. ft. /day
   b. 6 GPD/sq. ft. /day
   c. 8 GPD/sq. ft. /day
   d. 10 GPD/sq. ft. /day

CHAPTER X

CHLORINE CONTACT BASINS AND DISINFECTION

CHAPTER X

Chlorine Contact Basins and Disinfection for Lagoons

Purpose

The primary use of chlorine in sewage treatment is for disinfection of plant effluent before it is discharged into the receiving stream or water. The purpose of chlorinating sewage effluent is to destroy or reduce harmful bacteria in the sewage to safe limits, especially where the receiving water is used for water supply or for recreational purposes.

Theory and Methods of Operation

When chlorine is added to a lagoon effluent, a large portion of the chlorine is consumed or used up. This is called the chlorine demand. The portion of the chlorine that remains in solution is called the chlorine residual. The chlorine dosage minus the chlorine demand equals the chlorine residual. Only by having an adequate chlorine residual at the end of a specified period of retention time, can we expect to receive proper disinfection.

What happens when chlorine is added to a water environment? Will we have a free chlorine residual? A few facts should help to clarify these questions.

Chlorine can be purchased and utilized in wastewater treatment in a gas, solid, or liquid form. The gas form of chlorine is 100% pure chlorine; therefore, it is said to be 100% available. The most common type of granular chlorine is High Test Hypochlorite (HTH). HTH is only 70% pure chlorine and is more expensive to purchase than chlorine gas. Chlorine liquid is the most expensive form of chlorine and it is available in many strengths when purchased commercially. One of the most commonly used forms of liquid chlorine is

household bleach which is approximately 5% to 6% pure chlorine.

When chlorine gas is dissolved in water, hypochlorous acid (HOCl) and hydrochloric acid (HCl) will be formed. The hypochlorous acid is what causes disinfection to take place. When the granular or liquid form of chlorine reacts with water, a hypochlorite solution will result. The granular form of chlorine produces calcium hypochlorite ($Ca(OCl)_2$). The liquid form of chlorine reacts to make sodium hypochlorite (NaOCl).

Hypochlorous acid (HOCl) and the hypochlorite ion (OCl) both are forms of free chlorine. Of these two forms of chlorine, hypochlorous acid is the better disinfectant.

There is another form of chlorine residual that can be measured called "combined" chlorine. Combined chlorine is formed when the chlorine reacts with the ammonia compounds present in the wastewater. Combined chlorine is not nearly as good a disinfectant as free chlorine. The various chlorine ammonia compounds are called chloramines. The only chloramine that is of any real use as a disinfectnat is the monochloramine (NH_2Cl).

The dosage required for safe disinfection will vary with the degree of treatment that the sewage has received. From 5 to 12 ppm will ordinarily be needed to safely disinfect effluent from a trickling filter plant. A chlorine residual of 0.5 ppm after 20 minutes' contact time after adequate mixing should be maintained unless higher residuals than this are required by the state. One test for chlorine residual is the orthotolidine test; however, NPDES now requires either the amperometric or iodometric procedure.

B.O.D. Reduction - While the use of chlorine should not replace other necessary processes in treatment of sewage, it does reduce the B.O.D. or strength of sewage about 2 ppm for each ppm of chlorine added. This rate of reduction of B.O.D. is effective until a residual has been reached.

Other Uses - While disinfection and B.O.D. reduction are the two most common uses for chlorine in sewage treatment, many other benefits may be derived from its use. Among these are odor control, filter ponding control, filter fly control, digester foaming control, sludge bulking grease removal, and aid to settling. These other uses will necessitate chlorination in units and places other than in the chlorine contact basin. Chlorine may react with other chemical substances in the water and lose some of its effectiveness as a disinfectant.

Equipment

Chlorine is generally applied to water through (1) a solution feed vacuum chlorinator, (2) direct feed pressure chlorinator, or (3) a hypochlorite pump (hypochlorinator).

A. Chlorinators are devices for feeding an aqueous solution of chlorine gas into water.

(1) With respect to the method of feeding the chlorine to the water, there are direct feed and solution feed chlorinators.

(2) With respect to devices for controlling the flow of gas within the chlorinator, there are pressure types and vacuum types.

(3) With respect to the control or dosage there are manual, semi-automatic and automatic chlorinators.

(4) A direct feed chlorinator is one with which the chlorine is applied directly in the form of gas to the water being chlorinated.

(5) A solution feed chlorinator is one in which the gas is first dissolved in a minor flow of water and the resultant chlorine solution fed to the desired point of application.

(6) Chlorinator settings are on 24-hour bases. For example, a chlorinator set on 24 lbs. will feed 1 lb. per hour or 24 lbs. in in 24 hours.

B. Hypochlorinators are devices for feeding a hypochlorite and water solution to the desired point of application.

(1) These feeders are small positive displacement diaphragm pump, for forcing the solution into mains under pressure.

(2) Dosage rate is controlled manually by adjusting the strength of the hypochlorite solution and by varying the rate of pumpage.

(3) Automatically controlled hypochlorinators are also available.

Typical Chlorinator Installations

A. Manual control chlorinators maintain a uniform rate of chlorine feed at any set rate until changed by hand.

B. Semi-automatically with starting and stopping of flow or pumpage but feed at the rate set manually.

C. Automatic chlorinators are provided with devices which automatically control feeding of chlorine in proportion to rates of flow or pumpage.

Handling Chlorine Gas

A. Chlorine containers

(1) Available in 100 lb and 150 lb cylinders

(2) One ton cylinders (containers)

(3) Tank cars

B. Transfer and storage

(1) Shipping and moving

(a) Trucks

1. Transport 150 pound cylinders in upright position.

2. Transport ton containers (cylinder lying down on side).

3. Securely fastened.

4. Hydraulic lift for uploading or suitable skid.

5. Hoist for ton container.

(2) Storing

(a) Store 150 pound cylinders in an upright position.

(b) Store ton containers on their side

(c) Arrange so leaking container can be easily moved. A gas chlorine leak can be detected by the use of ammonia.

(d) Store chlorine in cool, well ventilated area.

(e) Protect from sunlight and precipitation if stored outside.

(f) Storage and feeding areas should be located above ground level, and in separate room.

(g) Practice good housekeeping

(3) General

(a) Follow suppliers instructions for rate of withdrawal from cylinders.

(b) Follow suppliers instructions for inspection of valves, fusible safety plugs etc. Also for handling and storage of empty cylinders.

Design and Loading of Basin

Chlorine contact basins may be either square, rectangular or circular in shape. The bottom may be either flat, sloping or hoppered, depending on the method used to remove settled solids. Some tanks are equipped with humus pumps for this removal; others are equipped with mechanical sludge rakes. The usual designed detention time is at least 10 minutes (A longer detention time, possibly 30 minutes, may be required under certain conditions)

Difficulties Frequently Encountered

Difficulties involved with operating of chlorine contact basins are usually traced to poor maintenance of equipment.

Records

Daily records should include pH, B.O.D., D.O., chlorine residual, settleable solids, daily flow, pounds of chlorine used, and any other sample required by the state on final effluent. Generally, fecal coliform analyses are required at specific intervals if the operating permit requires disinfection of the effluent.

Hypochlorinators

The usual type of equipment used for metering hypochlorite solutions is a positive displacement diaphragm pump of which there are three general types:

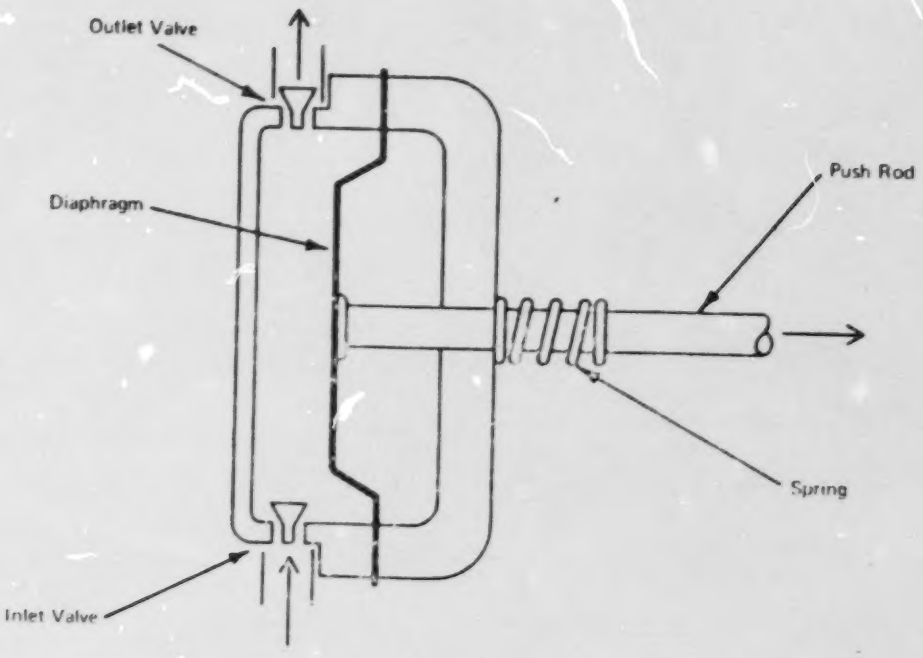
Mechanically Actuated Diaphragm: This type of pump (See Figure on page X-8) employs a flexible diaphragm to isolate the hypochlorite solution from the operating mechanism. The diaphragm is mechanically attached to an actuator push rod which is caused to reciprocate by the operating mechanism. The diaphragm is generally circular in shape and convulated to allow the diaphragm to flex rather than stretch.

Usually, a spring return mechanism is employed to return the diaphragm from its extended position.

On the suction stroke, the diaphragm develops a partial vacuum within the liquid head. This closes the discharge check valve, opens the suction check valve, and allows hypochlorite solution to flow in the chamber.

At the end of the suction stroke, the push rod reverses direction and begins the discharge stroke. As the diaphragm is pushed into the feeding chamber, a pressure is created and closes the suction check valve, opens the discharge check valve, and forces the solution out of the head into the discharge line.

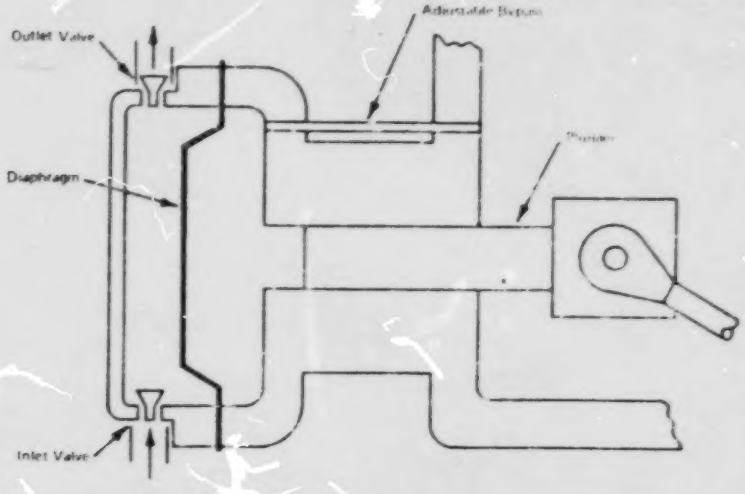
At the end of the discharge stroke, the push rod reverses direction and begins another cycle of filling and emptying the feeding head. Since the diaphragm is unsupported on one side, this type of pump is limited to low discharge pressure applications (usually pressures not exceeding 125 psig) which in turn permit use of different types of basic driving means; i.e., a solenoid may be used to actuate the push rod by push-pull action, or the push rod can be reciprocated by a mechanical device such as an eccentric operating from a gear reducer/electric motor drive, or a secondary diaphragm may be used, operated from a pressurized fluid, either water or air.



Mechanically Actuated Diaphragm.

Hydraulically Actuated Diaphragm (Plunger-Diaphragm): The hydraulically actuated diaphragm pump (See Figure on page X-9)employs a diaphragm to isolate the pumped liquid from the operating parts, but unlike the mechanically actuated diaphragm type, the diaphragm is supported on both sides. Perhaps the simplest generalized explanation of its design is to consider it as a combination of a plunger pump and a diaphragm pump in which the plunger pump is used as a source of pressurized liquid which is applied to the reverse side of the diaphragm which, in turn, pumps the hypochlorite solution. In this manner, neglecting minor flow losses, the diaphragm is said to be balanced, allowing its use at pressures many times higher than is possible with the mechanically actuated diaphragm pump. Also, since the plunger can now be enclosed in a non-corrosive liquid, the stuffing box-type packing can be replaced with a metal-to-metal seal.

In operation, the plunger is caused to reciprocate in a chamber filled with hydraulic fluid. The displacement of this fluid in turn causes the diaphragm to be flexed, alternately discharging and recharging the pumping chamber. Capacity control is accomplished by varying the volume of hydraulic fluid displaced by the plunger or by bypassing a portion of the fluid displaced by the plunger.



Hydraulically Actuated Diaphragm.

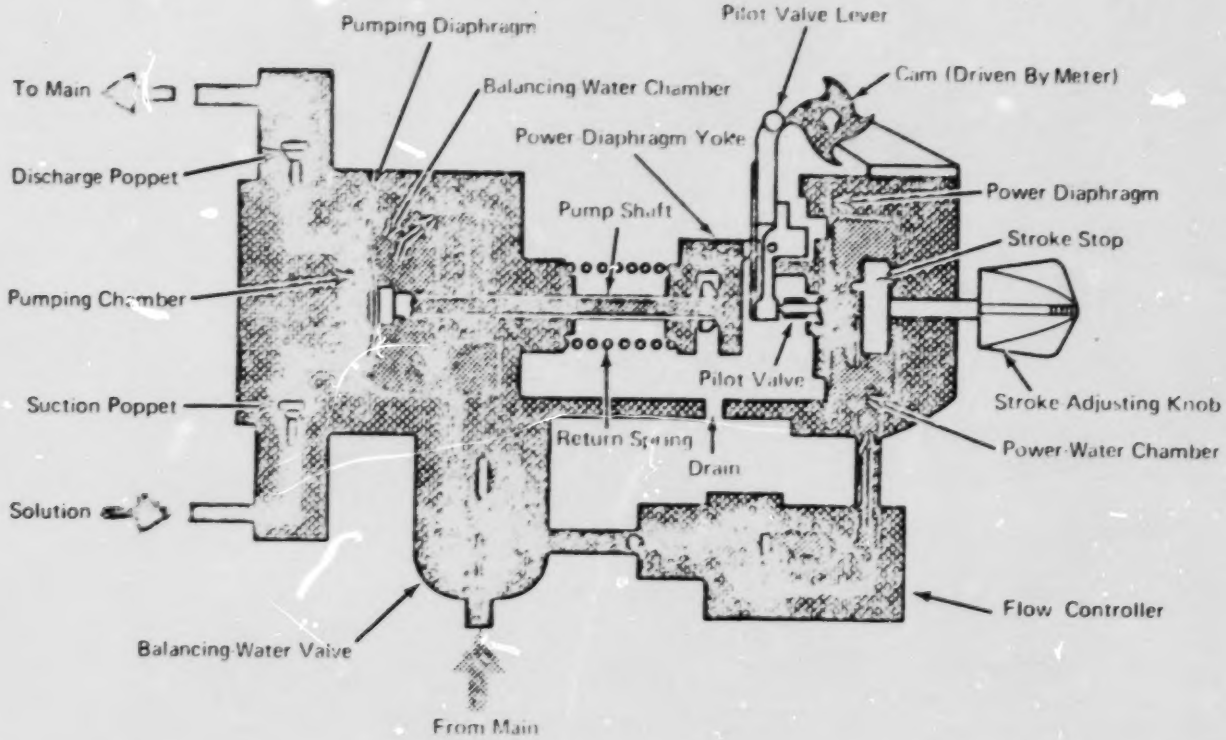
Hydraulically Actuated Diaphragm (Water Operated): Another type of balanced diaphragm pump is used in connection with a water meter in a pressure line. A mechanical linkage to the water meter operates a pilot valve that applies line pressure to a power diaphragm. Water pressure is also applied to the back of the pumping diaphragm to equalize the pressure against which the pump must discharge. A spring provides the suction stroke.

In some models the entire unit is mounted adjacent to the meter with a shaft from the meter head directly connected to the hypochlorinator. In others,

the pilot valve is located on the meter with tubing connected to the pump at a separate mounting.

This type of pump has two distinct advantages. No electric power is required for operation, and the hypochlorite solution is automatically proportioned to the flow of water through the water meter.

Methods of Control: Basic methods of regulating the feed rate of reciprocating diaphragm pumps involve changing the stroke length, or the stroke speed, or both.



Hydraulically Actuated Diaphragm.

Stroke Length Adjustment: This is usually done by restricting the length of the return (suction) stroke. Manual adjustment is by adjustment of a micrometer screw. Automatic control, proportioning feed rate in response to a water flow signal, can be done by a pneumatic positioner (usually 3-15 psi air) or an electric or electronic positioner which controls the return sludge length.

Manual adjustment is usually the only method of dosage control for hypochlorinators with internal electric motors, and for water-operated models. Conversely, all hypochlorinators have provisions for manual feed rate control.

Stroke Speed Adjustment: For hypochlorinators with external motors, stroke speed control is accomplished with variable speed drives accepting a pneumatic, electric, or electronic signal proportional to water flow. This can be done simultaneously with any method described above for control of stroke length.

As noted above, water-operated hypochlorinators are paced automatically by the water meter, which changes the stroke rate.

Shown below is a summary of the most commonly used control modes.

	Stroke Length	Stroke Speed
Manual	Variable for dosage	Constant
Start-Stop	" " "	On-off power circuit
Automatic flow proportional	" " "	Variable speed drive
or	Positioner with ratio control for dosage	Constant
Combined flow and residual control	Positioner controlled from analyzer	Variable speed drive

Maintenance: The parts of hypochlorinators most apt to require maintenance are the diaphragm and the valves. The diaphragm flexes continually in operation. Its life will depend on the strength of hypochlorite and the pressure it is operating against (in the case of mechanically operated models). The valves and seats may fail due to: (1) corrosion, (2) hardening or swelling, (3) scale or foreign material preventing proper seating.

All hypochlorite solutions are highly alkaline. This frequently causes the deposition of carbonate scale in the pump head, tubing, and the solution diffuser at the point of application. This can be readily removed by pumping a dilute (5%) hydrochloric (muriatic) acid solution through the pump. Be sure to flush out the hypochlorite with water first.

Special Care and Usage of Hypochlorites

High-test calcium hypochlorite is relatively stable under normal atmospheric conditions. However, reactions may occur spontaneously with organic materials such as turpentine, ether, oils, sugar, fats and other oxidizable materials. Hypochlorites should be stored and handled, therefore, using only clean dry implements free of oils, grease, and other organic impurities.

Because of its strong oxidizing powers and reactivity, calcium hypochlorite, especially in large quantity, should preferably be segregated or stored in a location separate from other chemicals or materials with which the chemical might react. For example, chlorine released from a leaking hypochlorite container in the proximity of activated carbon might be absorbed so rapidly that sufficient heat would be generated to cause the carbon to reach the ignition temperature and take fire.

Whenever a leaking or defective container is noted, it should be immediately removed from the storage area as it can rapidly cause corrosion of other containers and equipment in the area. Moisture, in addition to other factors mentioned, contributes to hypochlorite deterioration and indicates the desirability of storage in closed containers of such size that the contents will be consumed in a relatively short period, depending on process requirements.

Solutions of calcium hypochlorite are corrosive; thus, they should be handled in corrosive-resistant materials such as wood, ceramic, glass, plastic, or rubber lined steel vessels. For liquid feeding of high-test calcium hypochlorite, solutions of about one or two percent available chlorine content are usually recommended.

The corrosive nature of sodium hypochlorite also dictates the use of corrosion-resistant material for handling and dispensing, and the use of suitable personal protective equipment by persons involved in these operations. Accordingly, rubber gloves and aprons, goggles or other suitable protective apparel should be worn when one is preparing and handling hypochlorite solutions. In addition, every precaution should be observed to minimize splashing from the container. Accidental splashes should be treated immediately by removing affected clothing and washing it and all exposed parts with copious quantities of water.

Continuous Chlorination

To do the job properly, chlorination must be continuous. Therefore, provisions must be made in the design to provide scales for determining the quantity remaining in the connected cylinders. This type of system requires frequent checking and calculations on the part of the operator and leaves much to be desired. Manually manipulating a manifold with several cylinders connected

to it, usually results in either the chlorination being repeatedly interrupted or the operator finding himself in a bind with several partially or nearly empty cylinders connected to the system, a long period of plant unattendance at hand, and no room or facilities available to connect a full container.

A system has been available for several years to solve the empty cylinder situation, which automatically and instantaneously switches to a new supply when the connected cylinder or cylinders approach the empty condition. The empty containers may then be replaced by full ones, and the cycle is repeated. In most cases the capital outlay is less than required for provision of weighing devices, and the overall reliability of the system is greatly improved.

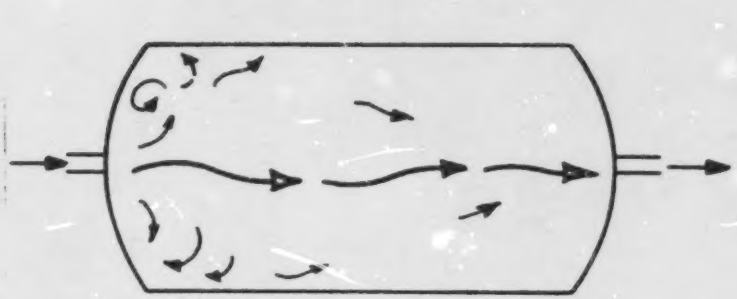
Contact Chambers

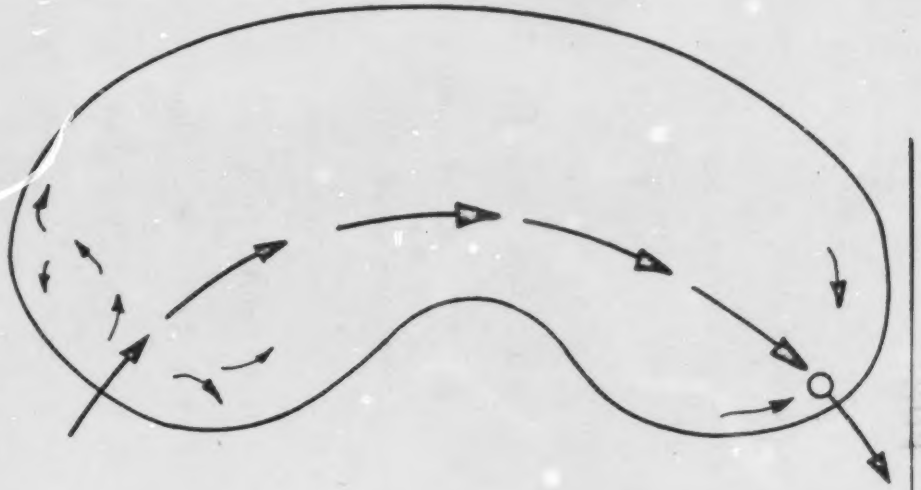
Sufficient technology and hardware now exist to do an effective job of disinfection and yet, many facilities which are properly equipped and staffed are not achieving the desired results. It would appear that the major deficiency at present is in the design and/or operation of chlorine contact chambers. For a variety of reasons they are not adequately performing the function for which they are constructed.

The matter of chlorine contact is obviously an important one in obtaining efficient disinfection of a treatment plant effluent. The nature of the contact facility is usually related to the space available, the remainder of the treatment facilities, flow patterns, effluent quality, costs, and other factors. This particular aspect has received considerably less attention than, say, basic processes such as sedimentation, biological reactor oxidation, and anaerobic digestion. Consequently, improvements are still being made in chlorine contact facility design. The figure on page X-16 shows examples of chlorine contact

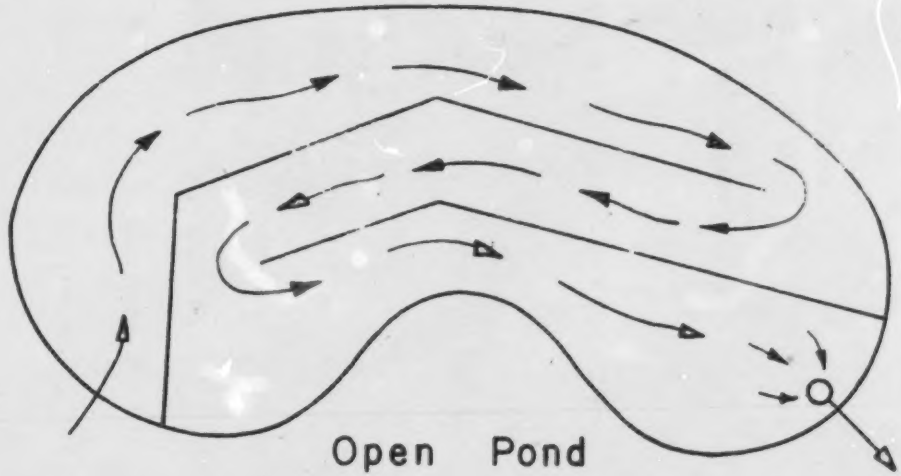
facilities. The pressure tank contact facility apparently had severe short-circuiting prior to diffuser inlet-outlet connections later provided. The kidney-shaped pond had short-circuiting before construction of baffles. These reduced but did not eliminate the short-circuiting. The most advantageous contact chamber is likely to be a serpentine pattern flow-through chamber somewhat as shown in figure on page X-16 . The flow is forced to take a long route, thereby preventing short-circuiting, other than the minor amount that may exist in any flow conduit. Apparently, it is being found beneficial to employ flash mixing of the chlorine solution with the wastewater flow prior to contact. This intimate mixing provides greater insurance that all volumes of the flow are adequately dosed. The other system depicted in the figure on page X-18 is one involving an existing plant whose oxidation pond effluent had previously not been required to be disinfected. The programmed chlorination facilities were designed to use a relatively small portion of the final oxidation pond as a chlorine contact basin, employing a substantial flow of water under pressure to dilute the chlorine solution and to inject the blended flow into the oxidation pond effluent as it moves slowly towards the effluent weir structure. The injection is by means of a diffuser loop as shown, and the velocities are such as to provide satisfactory initial mixing of the injected chlorine solution with much of the overlying water. The remaining mixing takes place by diffusion as the streams of flowing effluent converge in their movement towards the outlet.

The chlorination of oxidation pond effluents is another problem faced by the design engineer. Dave Caldwell's work at Camp Parks in the Livermore Valley during World War II on oxidation ponds is still cited in most of the literature.





Pressure Tank

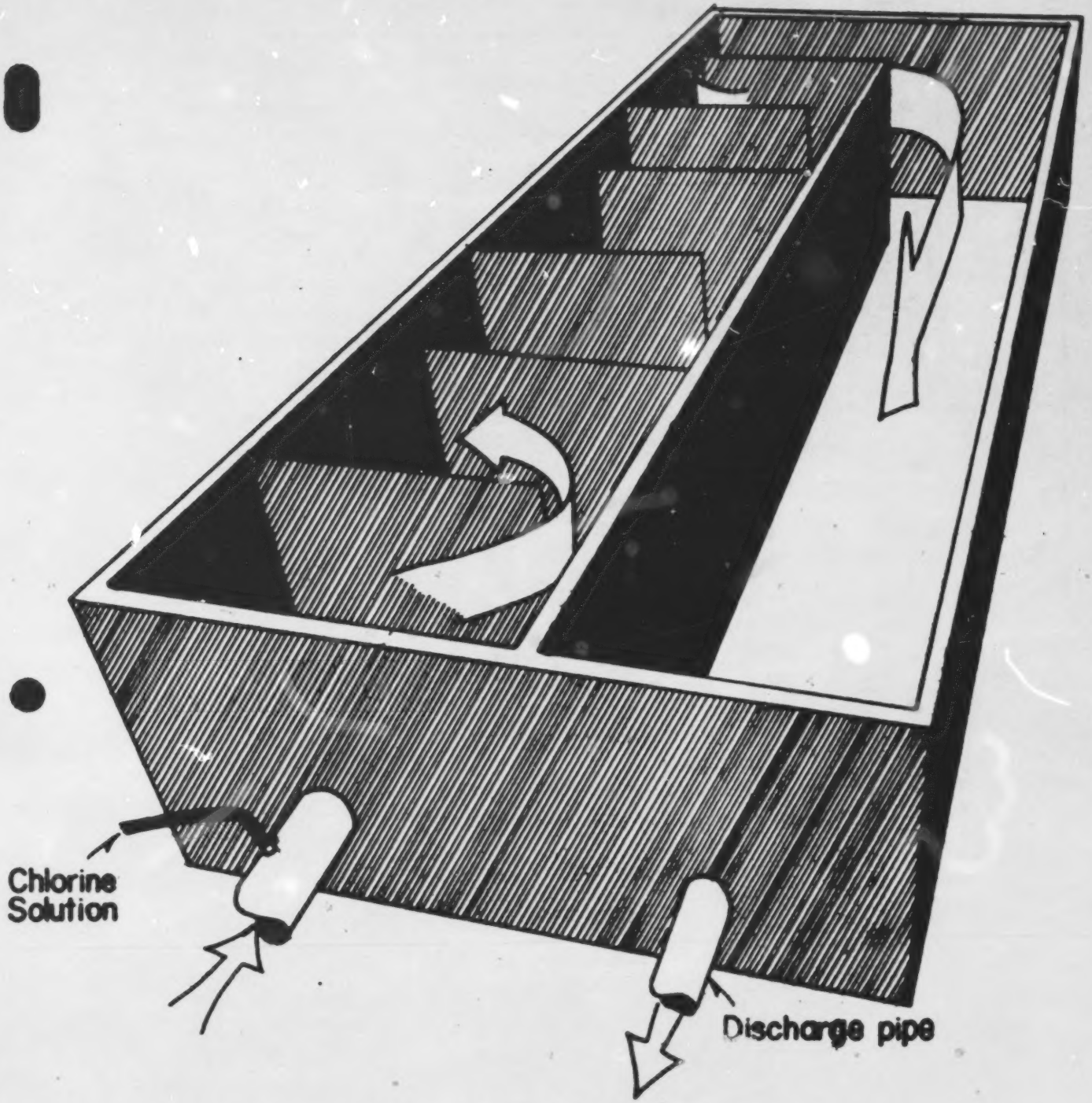


Open Pond

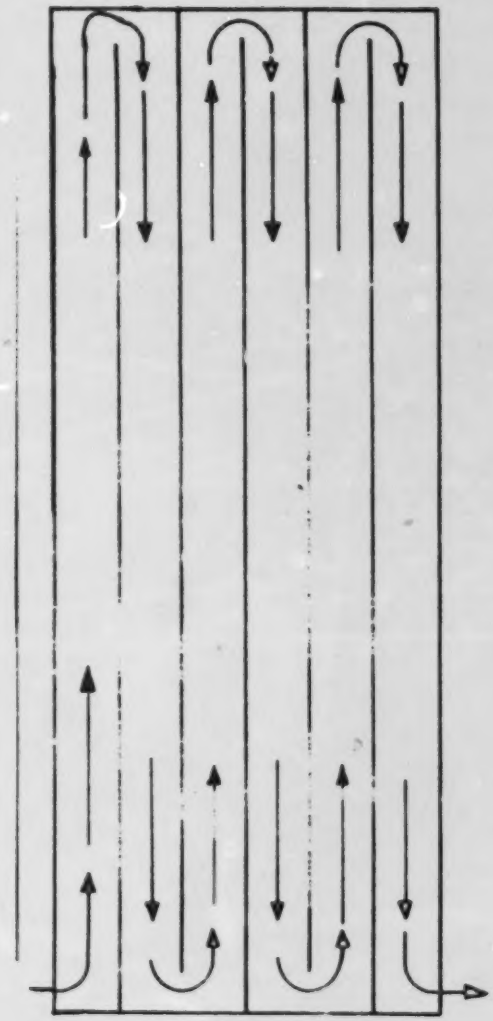
205

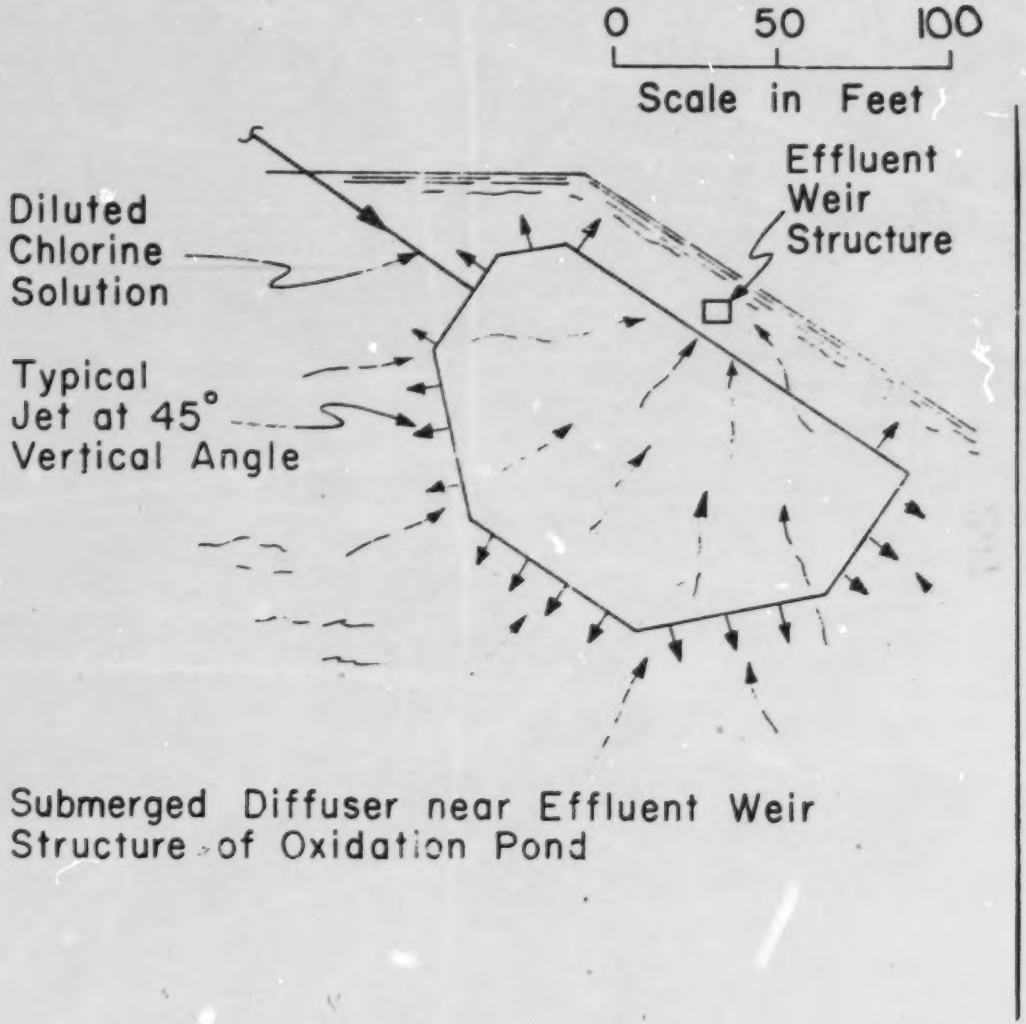
Examples of Chlorine Contact Facilities - A

206



CHLORINE CONTACT BASIN WITH BAFFEL MIXING





Submerged Diffuser near Effluent Weir Structure of Oxidation Pond

Figure 3 — Examples of Chlorine Contact Facilities - B

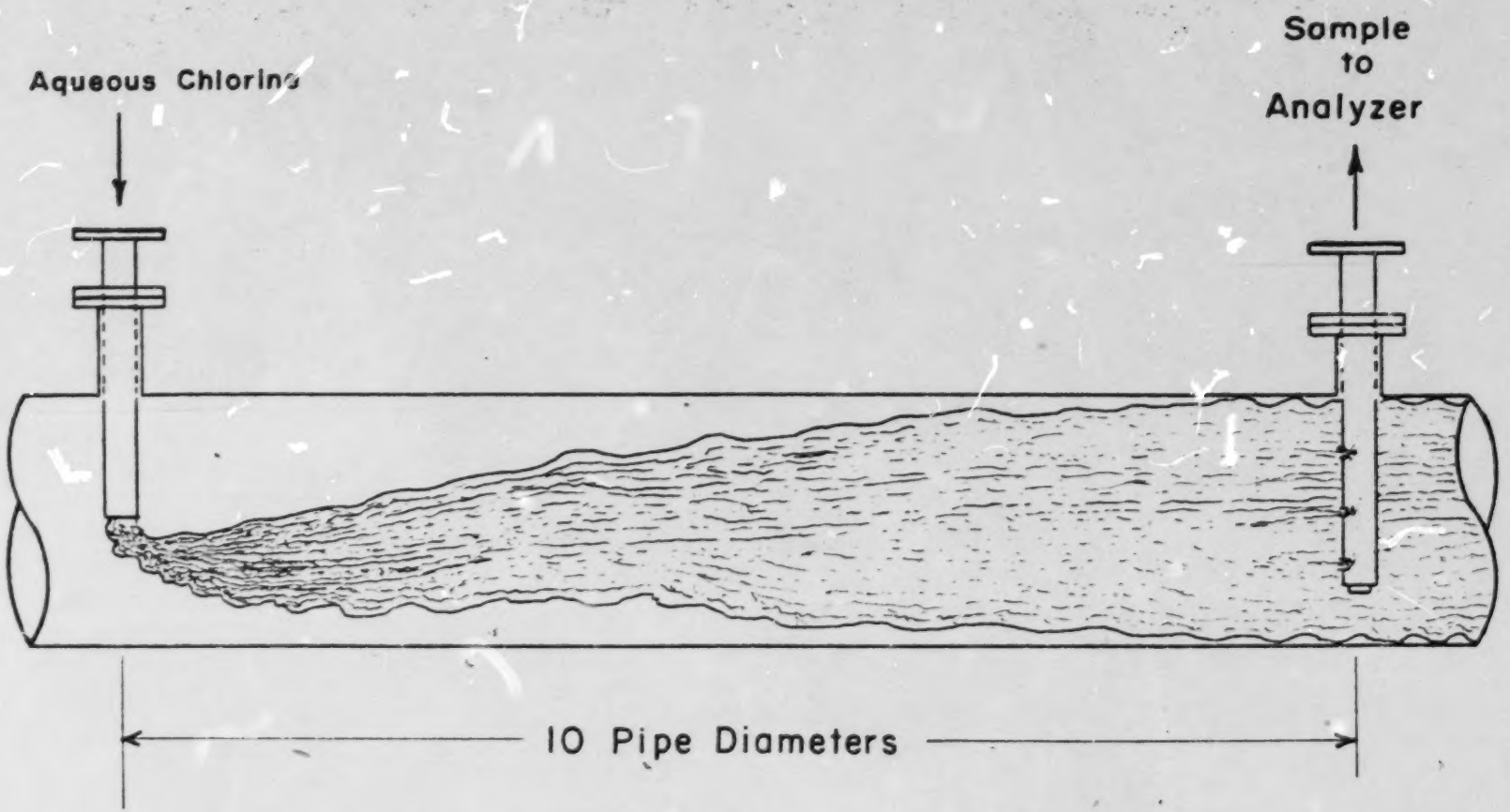
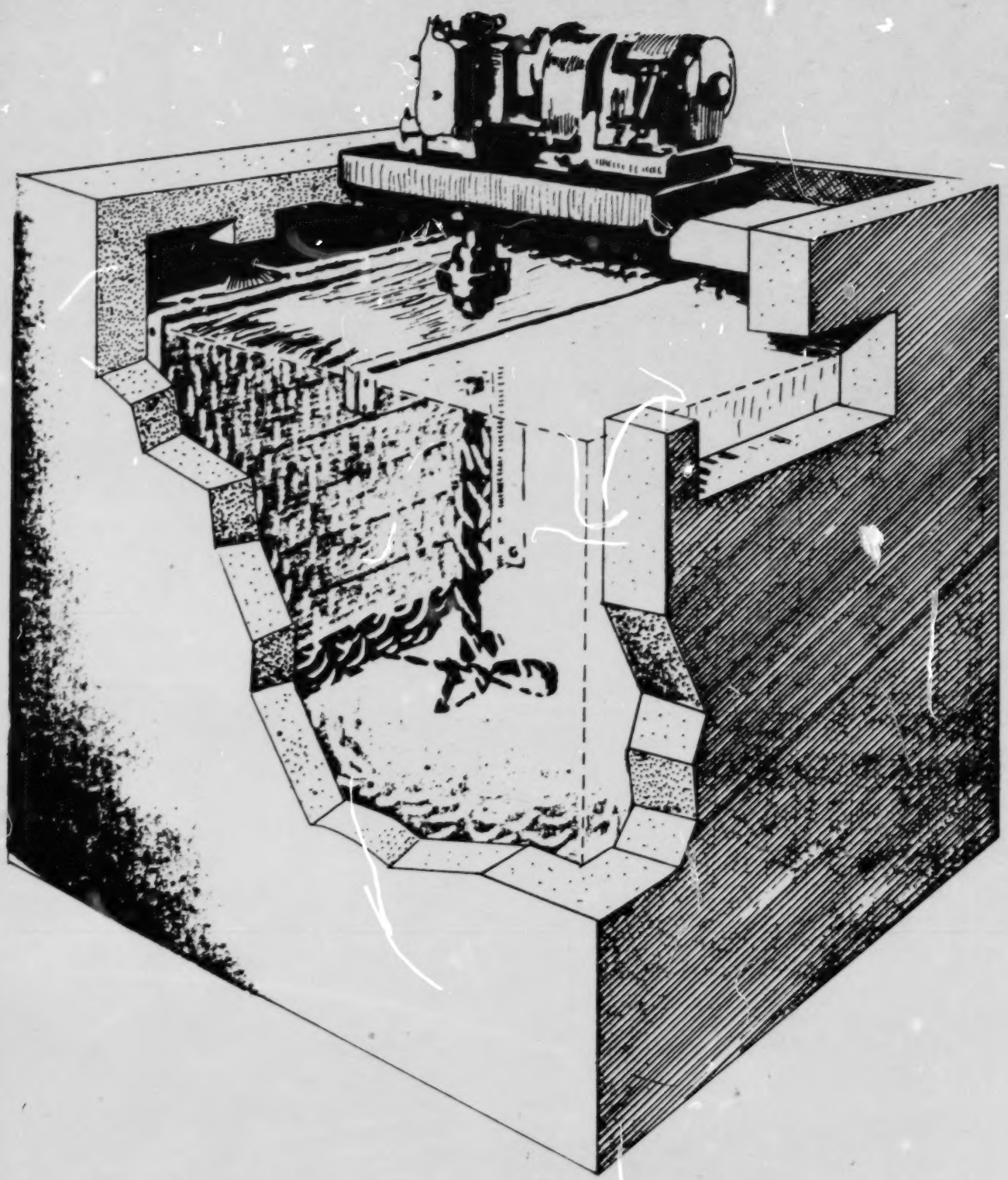


FIGURE 5. APPLICATION OF AQUEOUS CHLORINE TO A PIPELINE USING EXISTING TURBULENCE FOR MIXING



TURBINE MIXER X-20

X-21

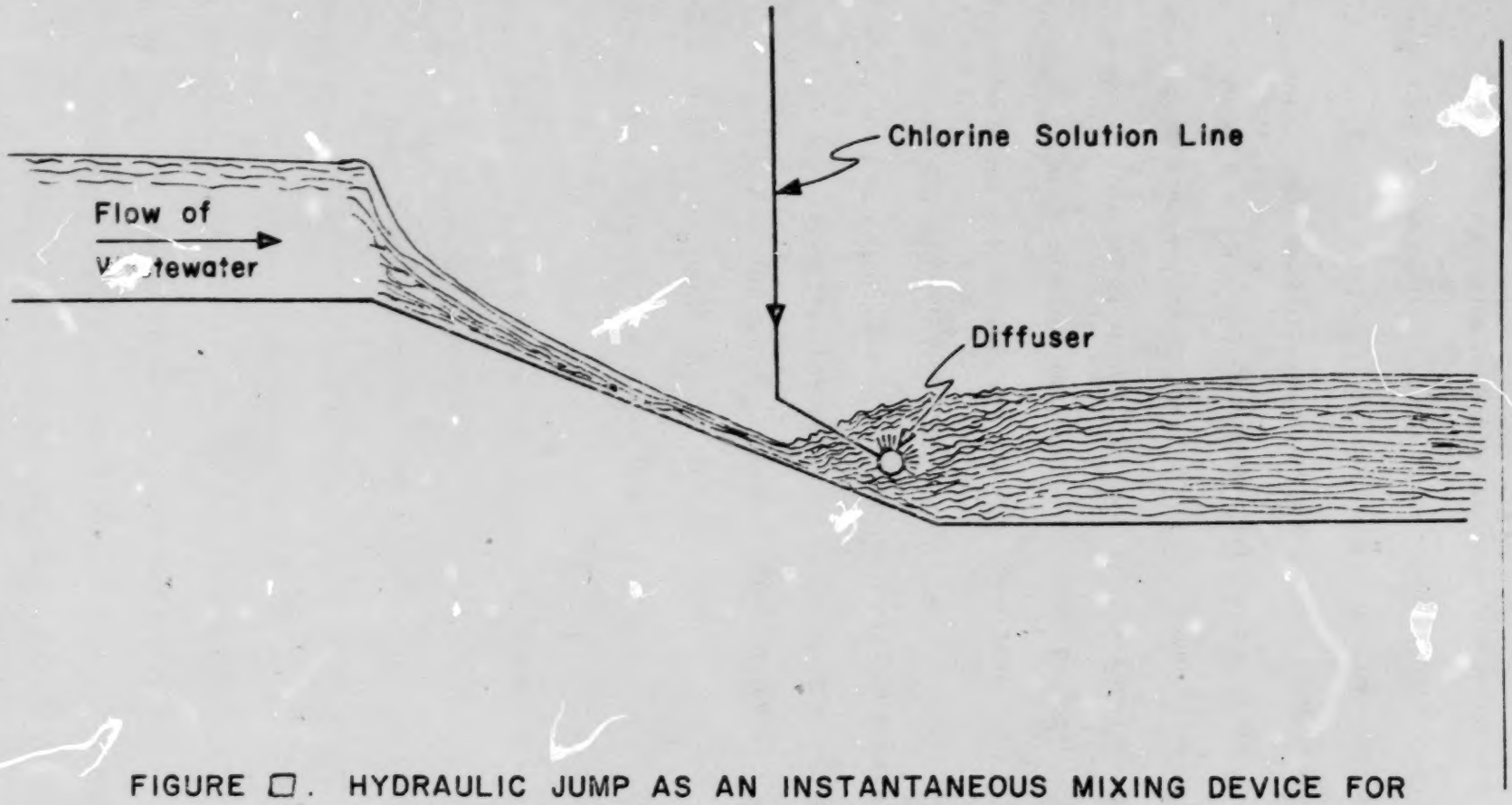


FIGURE □. HYDRAULIC JUMP AS AN INSTANTANEOUS MIXING DEVICE FOR CHLORINE AT THE POINT OF APPLICATION IN WASTEWATER TREATMENT .

The results of Caldwell's work, research and experiments are very interesting and enlightening but his complete report will not be presented in this manual. One conclusion is that rapid, complete initial mixing of the wastewater and chlorine is of great importance. This rapid (flash) mix should occur ahead (upstream) of the retention or "contact" basin, preferably inside a closed conduit or pressure pipe flowing full. Other methods of application are frequently used and are satisfactory if properly operated and maintained. Needless to say, that adequate mixing will provide a better kill than inadequate, slow mixing will provide with equal periods of retention or contact time.

Another conclusion is that if a mechanical mixing device is used, the chlorine feed should not be directly into the mixing device but that the chlorine be introduced into the wastewater ahead (upstream) of the mixing equipment.

Baffles constructed in open flow channels have provided effective mixing at locations where the baffles are properly spaced, velocity provides turbulent conditions. Mixing chamber cannot be expected to give thorough mixing.

Although chlorine has been extensively used for many years as a disinfectant because of its effectiveness, availability and comparatively low cost, other disinfecting processes may be just as effective or more effective than chlorination. Some of these processes are disinfection with potassium permanganates, ozone and ultra-violet rays. It is too early to predict that one or more of these may eventually replace chlorine as the principal disinfecting agent, however, the cost differential "gap" is being closed, some may be less hazardous and others may be more effective against certain bacteria and viruses. In the wastewater field especially, chlorination and disinfection are terms that have

been used inter-changeably, but with other processes coming into more common usage the facility designers are now giving due consideration to all practical processes of disinfection.

Safety

Throughout the text of this chapter safety precautions have been given at appropriate places. Chlorine gas although not explosive, is hazardous because if breathed even in very small quantities is fatal. All precautions should be practiced at all times, whether in storing, handling or using. Storage rooms must have adequate forced ventilation. Heavy concentrations must not be entered except while wearing approved respiratory equipment. An excellent safety manual is available from your chlorine supplier. Why not ask for it. Similar manuals are available from water and wastewater organizations. All operating personnel should become acquainted with approved procedures in emergencies related to chlorine handling and use.

Chlorine like many other chemicals is very useful and beneficial if used properly but if not, it is hazardous. "Treat it with due respect and caution!"

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C D
2. A B
3. A B C
4. A B C D
5. A B C D
6. A B C D
7. A B
8. A B
9. A B C D
10. A B C
11. A B C D
12. A B C D E

EXAMINATION QUESTIONS

Chlorine Contact Basins and Disinfection for Lagoons

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter X, Chlorine Contact Basins and Disinfection for Lagoons. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. Chlorine in wastewater will:

   a. Increase the anaerobic bacteria
   b. Reduce the B. O. D. of wastewater
   c. Increase the B. O. D.
   d. Have a rotten egg odor

2. If a chlorinator feed rate control indicator is set on the 288 mark, how many pounds per hour will it feed when in operation?

   a. 12 pounds
   b. 288 pounds

3. Chlorinators should be located

   a. Outdoors
   b. In a separate room at ground level
   c. In an airtight room

4. Good chlorination of a sewage-treatment-works effluent as is usually practiced

   a. Kills all bacteria
   b. Renders the effluent safe to drink
   c. Kills a large percentage of the bacteria and reduces the disease-producing organisms to within safe limits
   d. Reduces the B. O. D. to zero

5. Chlorine should be added to wastewater continuously to

   a. Keep the plant equipment from breaking down
   b. Keep the plant effluent disinfected
   c. Keep the chlorine pipes from developing leaks
   d. Keep the chlorine supplier in business.

6. The difference between the amount of chlorine added to water, sewage or industrial wastes and the amount of chlorine remaining after a specialized contact period is defined as

   a. Chloramines
   b. Chlorine contact time
   c. Chlorine residual
   d. Chlorine demand

7. To protect the health of downstream water users, treatment plant effluents must be

   a. Sterilized
   b. Disinfected

8. Chlorine may react with other chemical substances in the water and lose its effectiveness as a disinfectant.

   a. True
   b. False

9. A gas chlorine leak can be detected by the use of

   a. Water on a rag
   b. Soap solution swabbed on all joints
   c. Household ammonia on a rag and swabbed around suspected areas
   d. All of these

10. Chlorine may be used in a treatment process to help prevent

    a. Bacteria growth
    b. Media from decomposing
    c. Corrosion

11. A test for chlorine residual is the

    a. Imhoff test
    b. pH test
    c. Orthotolidine test
    d. B. O. D. test

12. Amperometric equipment can be used for determination of

    a. Free chlorine residual
    b. Combined chlorine residual
    c. Total chlorine residual
    d. All of the above
    e. None of the above

CHAPTER XI

SETTING UP AND MAINTAINING RECORDS

CHAPTER XI

Setting Up and Maintaining Records

In order to have a first class treatment plant, records must be kept on plant operations. Among the records that should be kept are equipment lubrication, equipment maintenance, flow and pumping data, laboratory analysis records, and weather conditions. Weather conditions and flows can sometimes be correlated with changes in the efficiency of treatment processes.

Setting up and maintaining good records is well worth the time and effort spent. Good records aid in the operation, maintenance and design of treatment facilities.

It takes a considerable amount of time to set up a complete record keeping system. But, experience shows that good records make a more efficient operation. Well kept records make the task of report writing easier and more accurate.

The following is one method used in setting up a record keeping system:

1. First, set up folders on each piece of equipment.
2. Assemble together all the information available on the equipment, such as instructions, operation, maintenance and parts manuals. Put this information into the folder.
3. The next step is to set up a data sheet. Put on the sheet all the information to be found on the name plate of the motor, pump or whatever the equipment might be. After years of service on the equipment, you may not be able to read the name plate because of corrosion, paint, scratches or maybe it has even been knocked off.

a. You must have all this information when ordering parts and equipment.

b. Getting the wrong part happens often enough even when correct information is sent. Put this sheet in the folder.

4. You now have the folder finished. File it and explain your filing system to others in your organization who might need access to this information.

Next, set up your equipment maintenance cards:

1. Put the equipment name at the top of the card. The front of the card is to report maintenance to the equipment, giving date and what was done.
2. The back of the card is a checklist for weekly oil check and lubrication.
3. File cards in card cabinet so they can be found easily.

Keep an up-to-date set of blueprints in the office. The original blueprints of the plant will not be accurate, as the contractor will change some piping, etc., a little in most every job; however, you will be furnished with a set of "as builts".

A card can also be set up for valves.

1. The front should have such information as description of valve, size, location, turns to open and turns to close. If you don't know how many turns it takes to open or close a valve, you could hit a hard place half open and leave it for open.
2. The back of the card should have a diagram of the valve location, showing measurements from permanent structures.
3. File cards

When setting up your daily report and log sheet and daily equipment record sheet, try to include all the equipment. Some of these records you will need more often than others. However, it is a good preventive maintenace to go by each piece of equipment often. If trouble develops, chances are you will catch it before there is damage done.

Set up a maintenance report and log sheet--this sheet is to write up equipment not operating properly or making an unusual noise.

Monthly Report

The "Report of Operation of the Treatment Plant" to the state should be filled out daily, starting on the first day of each month and each day thereafter until the last day of that month has been reported. A copy of the report should be made and filed at the plant. The original report should be sent to the state by the 10th day of the following month. If a copy cannot be made, then two reports should be made out with one being retained at the plant. A copy of the monthly repor. can be found in the appendix.

Annual Report

The annual report to the municipality, sewer district (or other owner) is of great value. All areas of expense should be itemized as to supplier, cost, and for what purpose an item was used. A report of this type must be available for preparing a useful operating budget. Excessive power costs may indicate worn or defective pumping equipment or that hydraulic loading has increased. Excessive repair costs may indicate that replacement of a certain piece of equipment would be more economical than further repair. This equipment could include trucks, backhoes, tractors, and mowers, as well

as motors and pumps. Flow records plus all operating expense are a basic necessity for determining the average cost of treating a given amount of wastewater. Excessive expenditures for chemicals may indicate that proper operating procedures are not being used or that chemicals are being applied improperly or perhaps wasted. Fuel costs whether for heating or motorized equipment should be given special attention, whether purchased at retail outlets or by bulk delivery. Theft, leakage or careless usage can account for excessive fuel costs.

Personnel Records

These records should include the name, age, social security number, home address, telephone number and name of next of kin. If employers are known to have disabilities or handicaps, these should be recorded for use in making work assignments. Handicapped persons should never be given tasks which might be detrimental to their health or safety. Employees with special capabilities should be indicated on the record in order that they can be properly assigned to work with which they are familiar and can perform efficiently. The record should show the number of hours worked daily with general information on the type of work performed although the employee may be paid on a monthly basis. Tardiness, absenteeism, sickness, days of paid and unpaid leave, work habits, attitudes, etc., should be recorded for purposes of training and promotion. Insurance companies and unions may require that additional records be kept.

Inventory Records

Regardless of the size or type of wastewater facility a stock of tools, supplies, and spare parts must be maintained in accordance with anticipated needs.

Tools should be inventoried and replacements recorded stating whether tool was lost, broken, worn out and replacement cost. The record of supplies purchased will indicate whether surplusses are carried and also whether the supplies are used carelessly or as actually required.

An adequate stock of spare parts is extremely important, especially those parts that require frequent replacement. A record should be maintained not only for the purpose of re-ordering but also for determining the frequency of replacement. When replacements are unusually frequent, it may indicate inferior parts, improper installation, faulty lubrication or lack of preventive maintenance.

Emergency Operation Records

Most regulatory agencies require a systematic procedure for reporting accidental spills and the emergency discharge of untreated or inadequately treated wastewater. In addition to the report to the regulatory agency, a record should be kept by operating personnel. Included in the record should be information related to when, where and why the spill or discharge occurred. The nature or characteristics and the quantity of wastewater spilled belong in the record, all remedial and clean-up procedures should be recorded. Indicate whether "outside" help was required and if so, the source of this help, whether by mutual aid agreement, paid contract help or help from State

and Federal agencies. Information of this type could be of great value to a "new" or inexperienced operator, if and when similar emergencies occur in future times. Another type of information should always be recorded whether in the daily log or emergency record. This information relates to indications of emergencies that may be developing. Among these conditions may be excessive percolation or leakage from the oxidation pond. Unusual intrusions of ground or surface water that cannot be remedied by conventional surface drainage systems are almost sure to become a serious problem.

Rapid deterioration of dikes, flow structures and drainage systems should be recorded. These conditions, if not recorded and immediately brought to the attention of the proper official, are easily forgotten. Keeping good records is not necessarily an expensive, complicated task. The record system should be designed for simplicity and adapted to the needs of a particular treatment facility. Valid records are of great value and generally are worth the time and effort required. Poor records are almost worthless and are perhaps very little better than no records.

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

GRADE_____ CLASS_____

1. A B
2. A B C D
3. A B C D
4. A B C D
5. A B C
6. A B C
7. A B C
8. A B C
9. A B C D
10. A B

EXAMINATION QUESTIONS

Setting Up and Maintaining Records

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter XI, Setting Up and Maintaining Records. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. Well kept records will make the task of writing reports much easier.

   a. True
   b. False

2. Records are important because:

   a. Other cities may want to borrow them.
   b. They create a job.
   c. They aid in the operation and design
   d. They make good newspaper articles

3. A reasonably accurate operation report for a sewage treatment works

   a. Is of no value to anyone.
   b. Is of greatest value to the operator and to municipal officials
   c. Is of value only to personnel at the largest plants
   d. Is of value only to the state authorities

4. An operation report for a sewage works usually contains some information regarding daily rainfall, air temperature, and sewage flows. This information

   a. Means nothing as far as the efficiency of the sewage treatment process is concerned.
   b. Serves only to satisfy an operator's curiosity.
   c. Can sometimes be correlated with changes in the efficiency of the sewage treatment process.
   d. Is the most useful data on the report.

5. Records are not useful unless they are:

   a. Bound and filed in the county courthouse
   b. Used as indicators of plant operation and maintenance
   c. Published in the local newspaper's public records section

6. Accidental spills and unauthorized discharges of wastewater should be

   a. Kept quiet to avoid unfavorable publicity
   b. Forgotten because it couldn't have been avoided and may never happen again
   c. Reported immediately in detail to the appropriate regulatory agency

7. Deterioration, settling and erosion of dikes, berms, and flow structures should be a matter of record because

   a. Wastewater facilities are designed to last for 20 years
   b. All workmanship and materials are under warranty for 10 years
   c. Maintenance records for the above items are just as important as other maintenance records

8. Good records should be kept because:

   a. The State Agencies recommend it
   b. Good records provide valuable information for operating personnel, owners, and regulatory agencies
   c. Visitors enjoy reading the records

9. Poor records are those that

   a. Are written with a pencil
   b. Have mis-spelled words
   c. Are not valid and accurate
   d. Are written in cheap notebooks

10. In preparing an annual report salaries should never be included because these must be paid anyway and are not a part of operating expense.

    a. True
    b. False

CHAPTER XII

PUBLIC RELATIONS

CHAPTER XII

Public Relations

Public relations is simply the operating principle which molds public opinion. Every contact with the citizenry will affect and contribute to public relations whether good or poor.

The utility department which fails to keep the public informed, falls short of a basic objective; that is building a good will. It is easier and more effective to prevent crises in public attitudes than to cure them once they have developed. There are two principles of a good public relations program: (1) Do a good job...nothing builds good will, confidence, and respect more solidly than efficient service; and (2) let people know about it...there's no better way of getting your story told than by the news media.

A common misconception is to think of a public relations program as a publicity campaign to "toot your own horn". This could not be further from the truth. However, the department which fails to keep the public informed misses the opportunity to head off problems by explaining situations before they become a resentment in the minds of uninformed customers.

Newspaper reporters and television or radio broadcasters should never be treated like overbearing salesmen by appearing to be too busy to talk with them or making them feel they are taking up too much of your time. The department head should strive to improve relations with these people and reduce the percentage of unfavorable and incorrect stories.

The human element will always be the predominant factor in public relations. Behind the scenes of any progressive operation will be found trained and courteous employees, working as a team for the betterment of their organization

and the convenience of the public. The caliber of men and women on the team, the quality of their performance, and their personal attitudes toward the public all have a direct bearing on the success of the department as far as the public is concerned.

Complaints are highly important. They are the warning signals that guide an external public relations program. When these grievances begin to mount up, they indicate something is wrong and a correction is needed. If complaints are ignored, a bad situation may soon become worse.

Probably the first contact between the utility department and the customer is through a telephone conversation. Besides telephone calls seeking information, many calls are complaints about service problems. These calls especially should be handled tactfully and with courtesy. The customer may form an unfavorable opinion of the entire utility department because of the discourtesy of only one person. Many cities require their office personnel to be trained in good telephone manners. The telephone company will usually train employees free of charge by either a film or a telephone company representative coming to your place of business.

Good customer relations result from an advance notice to the customer of any sewage collection project in which the customer will be inconvenienced for some period of time. Excessively loud talk should be held to a minimum and the use of profanity should not be permitted.

After repairs, etc., job sites should be left in as good or better condition than before the repair started.

Good physical appearance is important. It has been found that a person

who practices good rules of appearance inspires the confidence and respect of the people he meets during the day.

It should be remembered that in the employee's particular neighborhood, he is "Mr. Utility Department" for that section of town. If fully informed on the operations of his department, he can accomplish a great deal in promoting public understanding.

Finally, and most basically, just being nice to people is an employee's best public relation asset.

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C D

2. A B C D

3. A B C D

4. A B C D

5. A B C D

EXAMINATION QUESTIONS

Public Relations

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter XII, Public Relations. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. Two principles to build consumers good will are:

   a. Smiling face and not doing a good job
   b. Doing a good job and keeping quiet
   c. Efficient service and an adequate publicity
   d. Doing a good job and being mean

2. To improve relations with the news media

   a. Treat them as a salesman
   b. Be courteous and discuss news releases with them on friendly basis
   c. Treat them as they are a nuisance
   d. Be courteous, but do not allow them to know you and your business

3. If someone complains about your service

   a. Ignore them as it is hard to please everyone
   b. Tell them that you will respond whenever you will have time
   c. Act immediately to correct the situation
   d. Tell them that nothing is wrong

4. Everyone in the department should be courteous as

   a. Everyone represents the department
   b. A consumer may talk to anyone and form the opinion about the whole department
   c. Courtesy does not cost much but buys a lot
   d. All the above answers

5. To inspire the confidence and respect of the public

   a. A good personal appearance is important
   b. Dress up the way you want
   c. A neat person shows that he is not doing his job
   d. A bad personal appearance

CHAPTER XIII

MAINTENANCE

CHAPTER XIII

Maintenance

What is Maintenance

There are as many answers as there are organizations. Even within an organization there are variations in concepts of maintenance.

In the field of sewage and industrial wastes, this apparent confusion is understandable if we consider the following facts:

1. There is a wide variation in the nature of water and wastewater.
2. A variety of processes and process combinations are used.
3. There are not two plants identical in size, layout, construction, location, or age.
4. There are no two plants identical in organization, personnel, operation or fiscal procedures.
5. There are many manufacturers producing a great variety of equipment in the field.

The conclusion is that a unique ready-made maintenance system applicable to any plant does not exist. However, there are certain features which are common to all. Therefore, the objective is to develop some principles of maintenance which can be used to understand or custom make a modern complete maintenance system for any specific plant.

For this purpose we shall define maintenance simply as the holding or keeping of property or equipment in a given condition, especially efficiency, at least cost.

Based on this definition, we can then say that the following are maintenance functions:

1. Inspection: This activity is the systematic periodic checking of structures, grounds and equipment to detect conditions that will cause breakdown or excessive depreciation.
2. Servicing: In this category can be included lubrication, adjustments, cleaning, replacing packing, seals and belts, painting, janitorial work, gardening, etc.
3. Repair: Repair is the replacement or restoration to good condition of defective or worn parts revealed by either inspection or breakdown.
4. Modification: Here we are concerned with the alternation of parts or changes in material to reduce costs or increase efficiency.
5. Replacement: This is the installation of a new or different unit in place of an existing unit which has become uneconomical or ineffective due to functional obsolescence, excessive operation or maintenance costs, or misapplication.

One important fact must be considered; that in every organization, there exists some arbitrary point beyond which modifications and replacement are not considered as being part of the maintenance budget; but become capital expenditures. However, operation and maintenance records are the foundations which justify such capital expenditures.

We have defined our goal and identified the primary activities to reach that goal. The way these factors are organized becomes a maintenance system or program which will contain secondary or supporting activities. The elements of a maintenance system may be broken down as follows:

1. Survey and catalogue: First step is to inspect and list all items of structure, equipment, etc., by units. This information is the foundation of the primary maintenance record, the unit history which should include at this point:

   a. For equipment: Manufacturer, Serial No. Type, Capacity or rating, service, installed cost (if possible), Dates of installation and initial operation.

   b. For structure or grounds: Contractor, Type of construction, Size in terms of number of floors and floor area, service, installed cost (if possible), date of completion.

The second step is to group and index unit histories in a logical manner, i.e., by location, type, service, etc. It is usually advantageous to cross index.

2. Decide what to do and when to do it: Initially this will be at best an intelligent guess on an analysis of available information derived from (a) the experience and knowledge of design engineers, constructors, manufacturers, others in your organization and yourself; (b) technical literature, and (c) operation and maintenance records that are available.

These instructions must be recorded in a way that will guide the supervisor and the persons performing the work. In other words, the recorded instructions become a part of a schedule which regulates activity.

3. Decide who will do what: The remarks in 2 above apply to this activity. In addition, these instructions or orders will also be influenced by the structure of a plant's parent organization.

4. Establish methods of performing work: The foundation of methods for equipment will be the manufacturer's service manual. The foundation for buildings and grounds maintenance may be accepted practice of the parent organization or derived from technical literature. To the foundation we will add the knowledge and experience of all concerned. The methods are composed of how to perform work and what material may be needed or used. The systematic convenient organization of written methods becomes the maintenance manual.

5. Set up material storage and procurement: Based on the work schedule and maintenance manual, a list of materials which must be on hand is prepared. The factors which control the contents of our storeroom are:

   a. Quantity used

   b. Frequency of use

   c. Availability from source

   d. Effect on operation or depreciation if work is delayed

It is important that the initial stock of spare parts and other supplies be conservative, since we do not want to have money tied up in items which are not critical, are infrequently used, or are readily available.

Do not attempt to list every part and piece in the plant. Commence with only those items which are known to be needed in the reasonable future. With time and experience, items may be added as needed.

A material control record is essential to let us know:

   a. What to have on hand

   b. When to reorder

c. How much to reorder

d. Identification for reordering

e. Identification of use

f. Potential vendors

g. Unit costs

These records should be indexed logically by name and an assigned number. The part numbers should be also recorded in the maintenance manual and, if circumstances warrant, in a catalogue which cross indexes units with materials.

6. Set up a means of determining unit maintenance costs: First we record by units in log or job order or combination of these, the work done and the time and materials used. This information is translated by accounting procedure into the following costs:

a. Labor

b. Material

c. Overhead

d. Total

Next, we enter the work done and its cost in the unit history.

7. Evaluate: In this activity we use past experience to predict the future. Without evaluation any maintenance system will fail since all conditions change with time.

To evaluate--we collect, condense, and relate the information contained in our records in the form of charts, graphs, tables, etc. These summaries enable us to:

a. Change our work schedule and maintenance manual to suit needs.

b. Estimate labor requirements and cost for control and budget use.

c. Estimate materials requirements and costs to control storage, regulate purchasing and use and to budget.

d. Know when and why to make or recommend modification or replacement.

e. Inform others of what has been accomplished and what we propose to accomplish in the future.

We have defined our goal, set up the functions to achieve that goal and have developed the elements of a system to carry out the functions. However, we may not be able to put our system into practice or will not be able to keep it working satisfactorily unless the following factors are included:

Paperwork: Records are necessary to inform, for comprehension, and as aids to judgement, but we must never forget that paperwork is the means to an end and not the end itself. The record system then should:

a. Be as simple as possible.

b. Include only information essential to performance, understanding or evaluation.

c. Be understandable to those who must make entries.

d. Be understandable to those who must perform work or make evaluations.

e. Report work done and costs in logical units.

f. Provide continuity of the maintenance system.

g. Avoid unnecessary duplication of effort.

h. Limit making and distribution of duplicate copies of various forms to the minimum necessary for the functioning of the system.

To develop a record system we can adapt an existing system of our parent organization or used at a similar plant; or we can enlist the services of suppliers specializing in record forms and systems. In either case we must use the above principles and judgement to tailor make the records to suit our own plant, organization or maintenance system.

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark the letter corresponding to the correct answer.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D E
6. A B C D
7. A B C D E
8. A B C D

CHAPTER XIII

Maintenance

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter XIII, Maintenance. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

One or more, none or all of the suggested answers may be applicable.

1. A "preventive" maintenance program may be defined as:

   a. Repairing equipment that has broken down mechanically.
   b. Inspecting equipment and reporting its condition to the mayor.
   c. Telling the supervisor that certain equipment is not functioning properly.
   d. Regular and systematic inspection of equipment, giving attention to lubrication, cleaning and adjusting according to manufacturer's recommendations.

2. Preventive maintenance should be performed at which time periods?

   a. When complaints are made.
   b. When convenient and when other work is finished.
   c. Regularly, on schedule as indicated by manufacturer.
   d. Twice each year on most equipment

3. Preventive maintenance programs are very important because:

   a. Wastewater facilities are designed to last for 20 years.
   b. All equipment is covered by the manufacturer's warranty.
   c. Most equipment is simple in design so anyone can "fix" it.
   d. Mechanical equipment performs a vital function in wastewater facilities and requires proper maintenance at specified times to avoid premature failures.

4. An effective preventive maintenance program is desirable because:

   a. Generally it is more economical to provide proper maintenance than to make repairs after mechanical failures occur.
   b. Bypassing of improperly treated wastewater may be prevented.
   c. It helps provide more work during winter months.
   d. Power bills can be held to a minimum when equipment is functioning properly.

5. Preventive maintenance should be applied to which of the following?

   a. Treatment plant pumps and motors
   b. Pump (lift) stations
   c. Collection lines (sewer mains)
   d. Tractors, backhoes and trucks, etc.
   e. Laboratory, grounds, buildings, fencing and access driveways

6. Which of the following can be classified as part of a preventive maintenance program?

   a. Cleaning and painting
   b. Keeping ladders, steps, grates, catwalks and railings in safe condition
   c. Mowing and rubbish removal
   d. Keeping a record of maintenance and repair on each major item of equipment

7. In order to perform efficiently, maintenance personnel should have:

   a. An adequate stock of spare parts which are used most frequently.
   b. A supply of spare parts for all equipment.
   c. A college education.
   d. A good working knowledge of the equipment being maintained.
   e. Suitable tools for performing routine maintenance.

8. Maintenance personnel should have considerable knowledge of safety and "First Aid" because:

   a. Toxic gases may be encountered.
   b. Explosive gases may be encountered.
   c. Pathogenic bacteria may be present.
   d. Carbon dioxide may be present.

CHAPTER XIV

NPDES REQUIREMENTS AND LABORATORY TESTING FOR LAGOONS

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NPDES REQUIREMENTS AND LABORATORY TESTING FOR LAGOONS

NPDES stands for the National Pollutant Discharge Elimination System, a new national permit program to control discharge of pollutants into the Nation's waters.

Created by the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), a new permit program replaces and improves upon the old permit system under the 1899 Refuse Act. It is part of the comprehensive effort set in motion by the 1972 law to prevent, reduce, and eliminate water pollution.

Enforcement

While the states retain primary responsibility to combat water pollution, they must now do so within the framework of a Federal law that contains real teeth. And if the states do not or cannot fulfill their responsibilities under this law, the Federal Government, through the U.S. Environmental Protection Agency (EPA), is empowered and directed to take action.

EPA is required to establish national effluent limitations and national performance standards for sources of water pollution including factories, power plants, sewage treatment plants, and animal feedlots. An effluent limitation is the maximum amount of a pollutant that anyone may discharge into a water body. Effluent limits may allow some or no discharge at all, depending on the specific pollutant to be controlled.

The law requires industries to use the "best practicable" technology to control water pollution by July 1, 1977, and the "best available" technology by July 1, 1983.

The law requires publicly-owned waste treatment plants to provide a minimum of "secondary treatment" by July 1, 1977 and to apply the "best practicable" technology by July 1, 1983.

The NPDES permit is the mechanism for insuring that effluent limits are met, that necessary technology is applied, and that all requirements of the 1972 law, for controlling discharges and complying with water quality standards are met on schedule. Under the 1972 law, it is illegal to discharge any pollutant into the Nation's waters without an NPDES permit.

A permit is not a license to pollute. On the contrary, a permit regulates what may be discharged, and how much. It sets specific limits on the effluent from each source. It commits the discharger to comply with all applicable provisions of the 1972 law. If the discharger cannot comply immediately, the permit sets firm targets.

The permit system also requires dischargers to monitor their wastes and to report the amount and nature of all waste components.

Penalties

Panalties for violating the law range from a minimum of $2,500 to a maximum of $25,000 per day and up to one year in prison for the first offense, and up to $50,000 a day and two years in prison for subsequent violations.

Any citizen or group of citizens whose interest may be adversely affected has the right to take court action against anyone violating an effluent standard or limitation, or an order issued by EPA or a State, under the law. Any citizen or group also has the right to take court action against EPA should EPA fail to carry out mandatory requirements of the law.

STATE OPERATED PERMIT PROGRAM

If a state wants to operate its own permit program, here's the procedure:

The state submits a complete description of its proposed program to EPA, along with evidence that state law gives it adequate authority to carry out the program.

EPA then reviews the proposed program to see if it meets all requirements. Some of the major elements that it must contain are:

The state program effectiveness must be at least equal in scope to the EPA program.

The program must be adequately funded and staffed with qualified personnel.

State law must make it illegal to discharge pollutants except under an NPDES permit.

The program must be legally enforceable in state courts. The state must have the power to compel compliance with national and state effluent standards and limitations, and water quality standards. Civil and criminal penalties must be at least equal to those in the 1972 Federal law, or high enough to be a substantial economic deterrent to violations.

The state must have the power to enter, inspect and monitor sources of pollution, and the authority to require polluters to install monitoring equipment, keep records, and file reports.

The state must have the power to immediately stop discharges that pose an imminent or substantial danger to public health or welfare. Lacking this authority, the State must have a procedure for immediately notifying EPA by telephone of actual or threatened emergencies.

The state must have the power to regulate the disposal of pollutants into wells.

To avoid potential conflicts of interest, anyone who receives, or has received in the two years previous a significant portion of his income, directly or indirectly from permit holders or applicants for a permit, may not serve on the state board or agency that approves permit applications.

The state must have an EPA-approved continuing planning process designed to produce water quality management plans for all navigable waters within the state.

The state's proposed permit program must provide for public access to all information, except trade secrets, generated in the permit process--permit application, tentative findings, fact sheets, discharge data, the permits themselves, monitoring data, compliance reports, etc.

The state's proposed program must provide an opportunity for a public hearing before a permit is issued or denied.

Obtaining a Permit

How does the owner or operator of a factory, a city sewage system, an animal feedlot, or any other source of discharges covered by the NPDES permit program go about getting a permit?

The first step is to obtain an application form.

If the state in which the discharge occurs does not have an EPA approved permit program an owner or operator gets the form from the appropriate EPA regional office.

The discharger then returns the completed form to EPA or the State agency, as appropriate, with the necessary fee.

The EPA Permit Process

After receiving the permit application, the EPA regional office evaluates it. EPA may ask the applicant for additional information and may inspect the site of the proposed discharge. If any additional information is sought by EPA but not delivered, EPA may deny the permit and impose sanctions on the discharger.

EPA sends a copy of the permit application to other Federal agencies for comments. The district office of the U.S. Army Corps of Engineers, for example, evaluates the impact of the proposed discharge on navigation.

The State Permit Program

If a state water pollution control agency is handling the permit program, the application is processed much as EPA does it.

The state must send the EPA regional administrator a copy of the permit application. If EPA requests it, the state must require the applicant to submit additional information. The state must also send EPA a copy of any permit it proposes to issue. If EPA objects, the state may not issue the permit. (EPA may waive its right to review certain permit applications submitted to a state by individual dischargers or by categories of dischargers).

After analyzing the application, the state then makes its preliminary decision to issue or deny the permit. If more than 500,000 gallons are to be discharged on any day of the year, the state prepares a fact sheet on the proposed permit.

The state announces its tentative decision publicly, makes the information available to the public, and provides an opportunity for a public hearing, as does

EPA. After allowing at least 30 days for comments and requests for a public hearing, the state issues or denies the permit. The state must also send EPA a copy of every permit it issues.

The Permit

Any permit issued by EPA or a state must contain several elements.

The permit must specify which pollutants may be discharged and must set average and maximum daily limits on those discharges as needed to meet effluent standards and limitations, water quality standards, and any other Federal or state requirements.

If the discharge is not in compliance with all applicable standards and effluent limits, the permit must require the discharger to take specific steps to achieve compliance no later than July 1, 1977.

EPA EFFLUENT CHARACTERISTICS REQUIRED BY JULY 1, 1977

	Monthly Average	Weekly Average
BOD_5	30 mg/l	45mg/l
TSS	30 mg/l	45 mg/l
Fecal Coliform	200/100 ml*	400/100 ml*
pH	6.0 - 9.0	

* of sample

Some states have set a more rigid standard than EPA.

Reporting Requirements

The permit for most municipalities requires:

a. Monthly samples for the five parameters listed.

b. The results of these samples are generally reported four times per year.

These periods generally end on the last day of March, June, September, and December. There are twenty-eight days to complete the report and submit it after the end of the period.

c. Records must be kept for a period of three years, longer if requested by EPA or the state. Records such as method of analysis, date, and time samples were taken and by whom, must be kept together for inspection, but should not be submitted with the monitoring report.

ROUTINE WASTEWATER ANALYSIS

The composition of wastewater may change greatly from day to day and from hour to hour. To operate a wastewater treatment facility efficiently, tests must be made that will disclose the condition of incoming sewage and indicate the degree of treatment it receives in each unit process. Proper interpretation of these tests will enable the operator to adjust or regulate the treatment processes to obtain the most effective treatment.

SAMPLING

The collection of a representative sample is the first step in the analysis of sewage; remember, "A test is no better than the sample and the sample no better than the manner in which it was collected." When taking a sample, the dipper, or other sampling device should be clean before using to collect the sewage and the sample should be taken at about mid-depth of the influent or effluent. This is especially important when taking samples from flow channels to avoid scraping solids from the bottom or getting floating solids from the surface. Accurate records must be maintained, as to sample location, date, time of day, temperature and weather conditions. Samples should be refrigerated at 2^{o} to $10^{o}C$ if there is a delay in running the tests.

GRAB SAMPLES

Grab samples are those samples collected at any desired point at any desired time. This type of sample may be used when testing for certain conditions of sewage at a particular time and place. Grab samples are used for pH, Fecal Coliform, temperature, Chlorine Residual and dissolved oxygen. Grab samples may be used for COD_5, COD, and total suspended solids.

TIMED GRAB SAMPLES

A timed grab sample is used to determine efficiency of a plant unit. A sample of the effluent is collected at a time corresponding to the detention time of the plant unit.

COMPOSITE SAMPLES

A composite sample is collected at predetermined intervals over a specified period of time and mixed together; in other words, a composite sample is a series of grab samples poured together to make one sample. For example, a 24 hour composite sample is usually collected every hour over a 24 hour period. Some composite samples may be limited to an 8 hour sampling.

PROPORTIONAL COMPOSITE

The proportional composite or weighted composite sample is one that is collected and related to flow at time of collecting. The higher the flow the larger the grab sample to be added to the composite.

FREQUENCY OF SAMPLING

Daily sampling is desirable in most plants. However, when composite samples are required, it becomes necessary to collect samples at a predetermined time. There are other benefits derived from sampling and obtaining readings from

meters, gauges, etc., every two hours, because this puts the operator by most of his equipment quite often, which is a good preventive maintenance schedule in itself.

To calculate the size of sample in ml use the following formula.

$$\frac{\text{Total volume of composite sample}}{\text{No. of grab samples}} \times \frac{\text{Flow Rate at Sampling Time in gpm}}{\text{Avg. flow, gpm}}$$

= ml of grab sample at sampling time.

Example:

$$\frac{\text{2000 ml (total volume needed)}}{\text{10 grab samples}} \times \frac{\text{20 gpm}}{\text{40 gpm}} =$$

A. $\frac{2000}{10} \times \frac{20}{40} = \frac{400}{4} = 100$ ml

B. $\frac{2000}{10} \times \frac{50}{40} = \frac{1000}{4} = 250$ ml

The composite jug or container holding the sample is stored at 2°C, (35.6°F) to 10°C (50°F) preferrably nearer 2°C, to prevent bacterial decomposition of the sewage. Proportional composite samples are used for BOD_5, and COD, and total suspended solids test.

KINDS OF TESTS

Many tests may be made on sewage to provide information about its condition and degree of treatment given. Below are tests recommended for National Pollutant Discharge Elimination Systems (NPDES).

Although not required by the state, many readings can be recorded and analyses performed that will help the operator do a better job with his plant's operation.

EPA prefers that the analysis be performed using Standard Methods. For The Examination of Water and Sewage, 13th Edition.

TESTS

SAMPLE POINT	TEST	FREQUENCY
Raw Sewage (Before Bar Screen)	Settleable Solids	Daily
	Suspended Solids	Weekly
	BOD	Weekly
	COD	Weekly
	pH	Daily
	Temperature	Daily
Final Effluent	**Alkalinity	Daily
	**Chlorine Residual	Daily
	**Settleable Solids	Daily
	*Total Suspended Solids (TSS)	Weekly
	*pH	Daily
	*BOD	Weekly
	**Dissolved Oxygen (DO)	Daily
	**Temperature	Daily
	*Fecal Coliform	Weekly
	**COD	Weekly
Stream (Above Plant)	DO	Daily
	pH	Daily
	BOD	Weekly
	Temperature	Daily
Stream (Below Plant)	DO	Daily
	pH	Daily
	BOD	Weekly
	Temperature	Daily

*EPA-NPDES Requirements
** Some states require in addition to NPDES Requirements. Although not a laboratory test, one of the 5 parameters for NPDES is flow measurement.

TESTS AND THEIR PURPOSE

SETTLEABLE SOLIDS

The results of the settleable solids test on sewage provide information on the efficiency of the settling units.

To determine the efficiency, two Imhoff cones are necessary, as samples

of both the influent and the effluent must be tested. The samples used in this test may be either grab, timed grab or composite.

The Imhoff cone is made of glass or pyrex, is cone shaped, and holds one liter when filled to the graduation mark near the top. The bottom of the cone is graduated in milliliters, usually 0 to 40 milliliters.

BIOCHEMICAL OXYGEN DEMAND (B.O.D.)

This test primarily measures the organic polluting material in a sample, and is, therefore, the most important test for determining the strength of sewage. This information may be valuable in determining the efficiency of the plant. The B.O.D. test may also aid in the studying of organic load or the receiving stream.

The samples used in this test may be either grab, timed grab or composite, although a 24 hour proportional composite sample is preferred.

There is a five day incubator period at 20°C. Domestic sewage will normally be in the range of 200 to 300 ppm BOD.

CHEMICAL OXYGEN DEMAND (C.O.D.)

This test determines the amount of oxygen required to oxidize (chemical oxidation) the organic matter in a waste (domestic and industrial) sample of sewage and should be approximately 450 to 600 ppm on the incoming sewage. The sample used for this test is usually a proportionate composite sample. If a correlation has been made between COD and BOD the COD test is a better operational control test because the results are available in 3 hours.

TOTAL SUSPENDED SOLIDS

Suspended solids are considered to be those solids in wastewater that can be filtered out. Suspended solids can be further divided into settleable solids and non-settleable solids. Suspended solids tests are conducted on either grab

or composite samples, but proportionate composite samples are preferred. Incoming sewage may have as much as 400 mg/l suspended solids.

DISSOLVED OXYGEN (D.O.)

This test determines the amount of oxygen that is dissolved in water or sewage. Dissolved oxygen is measured in mg/l or (ppm). Oxygen exists as a gas and is soluble in water only to a limited level, the amount depending upon temperature, salt content and other influencing criteria, such as altitude. Water @ 20°C and @ sea level will be saturated with oxygen when it is 9.17 mg/l.

A great deal of plant and animal life that exists in water, from large fish to the extremely small microorganisms, depend on the D.O. to sustain life. As man cannot live without oxygen, neither can these forms of plants and animals. Drive off the D.O., or use it up, and most of the needed plant and animal life will disappear in aquatic systems such as streams receiving the plant discharge.

An important factor to remember is that this test should be performed as soon as possible after the sample is collected and must always be a grab sample. It is best to analyze several samples taken at different times during the day. The sewage coming into the plant should have dissolved oxygen present. If the sewage has no dissolved oxygen the sewage will be septic and problems will be encountered.

HYDROGEN ION ACTIVITY (pH)

pH is the measurement of acidity or alkalinity of a solution. The pH scale is from 0 to 14 with 7 being neutral. If the pH of the solution is below 7.0, the solution is said to be acid, if the pH is above 7.0, it is alkaline. The lower the

pH the more acidic it is, thus the higher the pH the more alkaline it is.

The effect of pH upon various processes of sewage treatment makes this one of the most valuable tests in sewage works operation.

An acid condition (low pH) of domestic sewage is usually an indication of septicity, and would be corrosive to metal and concrete. It may also be caused by acid wastes from commercial or industrial customers. A pH above 8.5 is considered too high in the incoming sewage and usually indicates a violation of the sewer use ordinances.

Grab samples must be used to conduct pH tests.

CHLORINE RESIDUAL

When chlorine is used for disinfection of sewage effluent, tests are necessary to determine if the chlorine residual requirement has been met.

The test for chlorine residual may be made by different methods. The simplest test for chlorine residual in wastewater is the Iodometric Method. This test is approved by Standard Methods (204A) and the EPA. Cost for the apparatus and chemicals is minimal. The Ortho-tolidine method is not approved for chlorine residual determinations for wastewater. After July 1, 1977, EPA will require the amperometric titration Iodometric procedure to meet NPDES guidelines.

That grab samples must be used to conduct chlorine residual (after 30 minutes) is recommended in most states. However, it is best to check with the individual states on their requirements.

FECAL COLIFORM

The fecal coliform test indicates the degree of contamination of the wastewater effluent by potentially harmful bacteria. Both the membrane filter and most

probable number (MPN) are acceptable as test procedures. If the sample is not prepared onsite, it should be refrigerated at 4°C and then prepared with (6) hours.

ALKALINITY

The alkalinity test can give an indication of several conditions in wastewater. The presence of abnormally high alkalinity may indicate an alkaline industrial waste. The determination of alkalinity levels at various points in a treatment plant is an aid to the proper understanding and interpretation of the treatment process. For example, in a lagoon operation the alkalinity will usually decrease as the lagoon progresses toward septic conditions. The alkalinity normally will show a 20 - 30 mg/l change before there is a significant change in pH, (usually 0.2 - 0.3) pH. It is therefore, recommended that an electric pH be used to run pH determinations on wastewater, especially if there are any industrial wastes to be treated.

WATER AND WASTEWATER TECHNICAL SCHOOL
EXAMINATION ANSWER SHEET

_____
Subject

NAME_____ DATE_____

CLASS_____ GRADE_____

Completely mark out the letter corresponding to the correct answer.

1. A B C
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C
9. A B C D
10. A B C D
11. A B C D
12. A B C
13. A B C
14. A B C D
15. A B C D
16. A B C D
17. A B C D
18. A B
19. A B C D
20. A B C

EXAMINATION QUESTIONS

NPDES REQUIREMENTS AND LABORATORY TESTING

Read each question carefully. Circle the letter for the corresponding correct answer. If you are not sure about which answer is correct, it is recommended that you look up the answer in Chapter XIV NPDES Requirements and Laboratory Testing. Completely blacken out the letter on the answer sheet that corresponds to the correct answer, fill out the heading, sign and mail to the Water and Wastewater Technical School, P. O. Box 370, Neosho, Missouri 64850.

1. The most important test for determining the strength of sewage is:

   a. Relative stabilization test
   b. Biochemical oxygen demand test
   c. Suspended solids test

2. The probable number of coliform organisms found in sewage is indicated by:

   a. CO_2
   b. DO
   c. MPN
   d. pH

3. Dissolved oxygen is measured in:

   a. mph
   b. fpm
   c. cfm
   d. mg/l

4. In sampling sewage for a B.O.D. analysis, the best results are obtained from:

   a. A 24-hour composite sample
   b. A grab sample
   c. A sample made up of two or three portions taken at times of high flow
   d. A 24-hour proportional composite sample

5. If you are informed that a large quantity of acid waste was accidentally discharged to the sanitary sewer in your city, you could determine when it reached the plant because:

   a. The dissolved oxygen in the raw sewage would exceed the saturation value
   b. The pH of the raw sewage would rise
   c. The pH of the raw sewage would be lowered
   d. The volatile portion of the suspended solids would be greatly increased

6. The B.O.D. is a term that refers to:

   a. Balanced oxygen determination
   b. Content of oxygen in sewage or stream water
   c. Organic matter in sewage measured as suspended solids
   d. Oxygen demand of polluting organic matter in sewage or stream water determined biochemically

7. The biochemical oxygen demand determination is ordinarily made on samples that have been incubated for a time period of:

   a. 1 day
   b. 3 days
   c. 5 days
   d. 20 days

8. The best procedure for determining the dissolved oxygen of a plant effluent is to analyze:

   a. A 24-hour composite sample of the effluent
   b. A grab sample of the effluent taken at noon
   c. Several grab samples taken at different times during the day

9. Samples for making laboratory tests on sewage should be:

   a. Collected at any time during the day
   b. Representative of the sewage to be tested
   c. Collected at the most convenient place in the treatment plant
   d. Diluted with a chlorine solution before shipping to the laboratory

10. Water with a pH of 5.0 is:

   a. Great for water supplies
   b. Easy on iron pipes
   c. Excellent for lawns
   d. Acid and corrosive to iron pipes

11. An incubator for the BOD test should be controlled at the following temperature, plus or minus one degree:

    a. 15°C
    b. 20°C
    c. 25°C
    d. 37°C

12. Why is the COD test a better operational control test than the BOD test?

    a. The oxygen demand is not caused by biological organisms
    b. Everyone uses it
    c. The results are available sooner

13. A representative wastewater sample would be:

    a. A composite sample
    b. A grab sample
    c. A peak flow sample

14. The Federal Water Pollution Control Act of 1972 requires all point discharges to have:

    a. County Discharge Permit
    b. A state and/or EPA approved discharge permit
    c. City discharge permit
    d. No discharge permit necessary for lagoon

15. Does the state have a legal right to inspect or monitor your discharge effluent, even though the discharge is on your private property?

    a. Yes
    b. No
    c. Maybe
    d. No, if you are controlling the effluent

16. If you have a discharge permit and are required to report your results four (4) times per year, you must have your report in the mail within:

    a. A week after the quarter period
    b. A twenty-eight day period after the quarter period
    c. A ten-day period after the quarter period
    d. A month after the quarter period

17. The records for wastewater laboratory analysis must show:

    a. General laboratory tests
    b. Specific data, place, date, and by whom taken as well as all the parameters required by permit
    c. That the wastewater treatment facility is efficient
    d. That some laboratory work has been accomplished

18. Laboratory records only need to be maintained for a couple of years then they can be discarded.

a. True
b. False

19. You want to obtain a proportional composite (of 6 samples) at your facility in an 8-hour day. What is the size of the first grab sample in millimeters if you want an overall sample size of 2000 ml, and the flow rate is 30 gpm with a 50 gpm average flow.

a. 100
b. 150
c. 200
d. 250

20. If you have a wastewater discharge on your property, and the run off goes down a road ditch or into a stream, could your neighbor or any citizen take court action against you?

a. No
b. Yes
c. No, because its on my property